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Exploring Science RED BOOK

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Acknowledgments

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(Acknowledgments continued on page 288)

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1 Interacting with Your Environment

1 Discovering your environment
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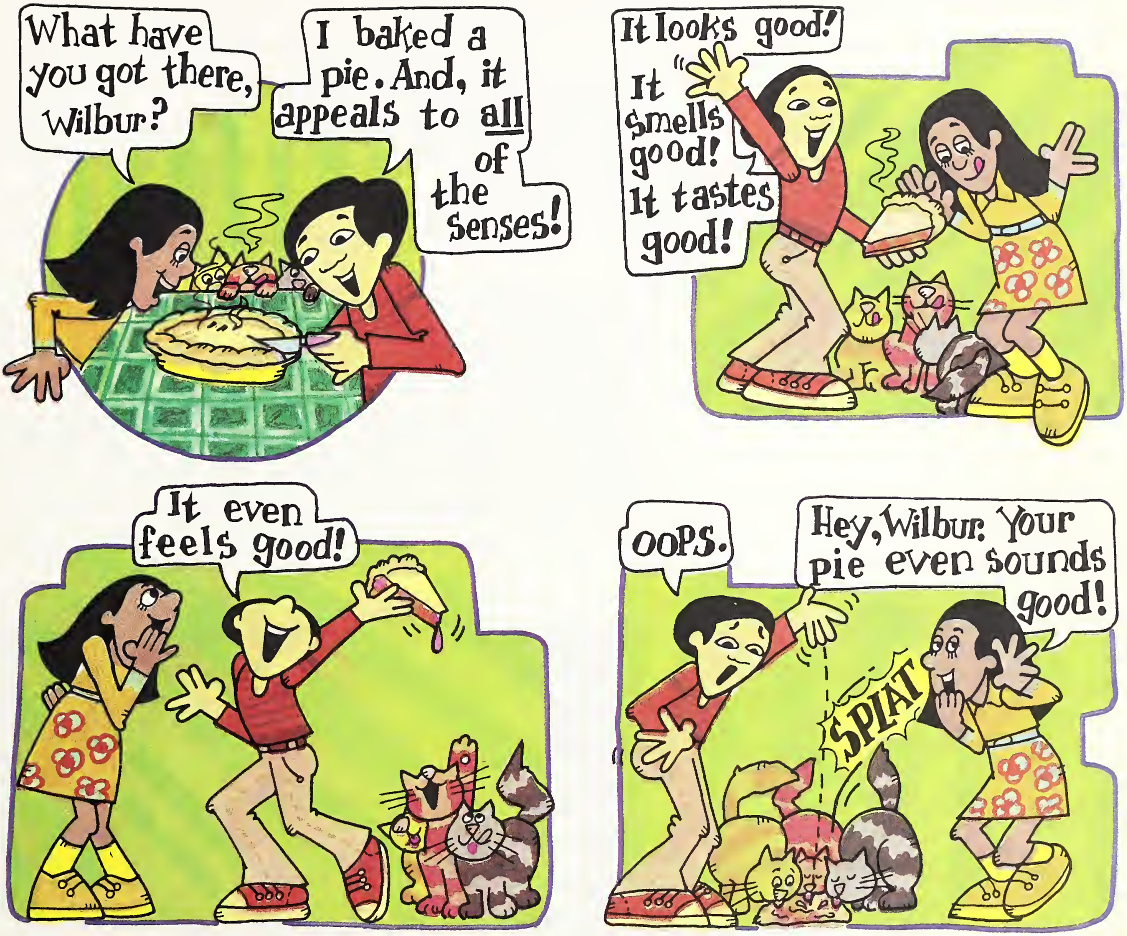

What have you got there, Wilbur?
I baked a pie. And, it appeals to all of the senses!
It looks good!
It smells good! It tastes good!
It even feels good!
OOPS.
SPLAT
Hey, Wilbur. Your pie even sounds good!

Besides foods, what other things around you do you find out about by using your senses?

Why is it important to be able to find out about these things around you?

1 Discovering your environment

Suppose you are sitting in your living room. And suppose you discover the following things without moving from your chair.

Cars are passing by outside.
Your sister or brother is in the room.
Someone is baking a chocolate cake.
The apple you are eating is sour.
You have something sticky on your arm.

You probably know that you discover things in your *environment* [ihn-VY-ruhn-muhnt], or surroundings, by using your *senses*. One such sense is sight. What other senses do you have? Which of your senses would you have been using if you had discovered each of the things stated above?

Using your eyes

Stop for a moment and see what things you can discover about your environment by using only your eyes. What are some of the things you discovered?

Within your eyes are special cells called *sensory neurons* [N(Y)OO-RAHNZ]. These neurons collect information about your environment. All your sense organs have sensory neurons which collect information about your environment.

Rods. Have you ever been outside at night when there is very little light? If so, you know that you can still see things around you. You are able to see with very little light because of certain sensory neurons in your eyes. These neurons are called *rods.* The rods are very sensitive to light. That is, they are able to "pick up" a very small amount of light. It is because of this that you can see at night.

Though you can see in very dim light, there are certain things you cannot see as well as you can in bright light. For example, in very dim light you probably can tell a very light colour from a very dark colour. But you probably cannot tell two light colours from each other. And it is equally hard to tell two dark colours from each other. How else is seeing in very dim light different from seeing in bright light?

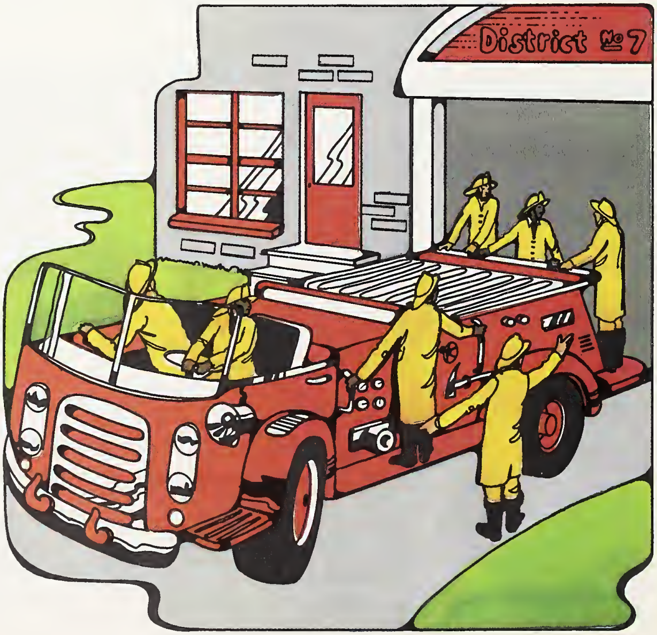
Cones. Besides rods, there are other sensory neurons in your eyes. These neurons are called *cones.* The cones are the neurons which enable you to see colour. Yet the cones are not very sensitive to light. Because of this, you need more light to tell colours from one another than you need just to see things.

For You to Think About

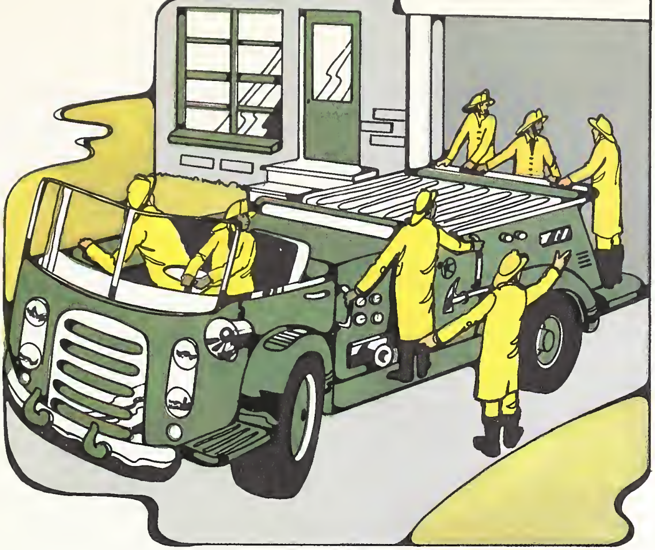
People who are blind often develop other senses to a much greater degree than people who are sighted. Which senses do you think would be more fully developed by people who are blind? Why?

Suppose you have three pieces of cloth. One is dark blue. One is dark red. And one is dark green. And suppose you place these pieces of cloth on a table in front of you. If you were to look at them, you would have little trouble telling one colour of cloth from another. But suppose you look at the pieces of cloth in a very dimly lighted room. Do you think you would be able to tell one colour of cloth from another very easily? Why or why not? Try it!

There are some people who cannot tell certain colours from other colours even in bright light. These people are said to be *colour-blind*. Most people who are colour-blind cannot tell red from green. Because of this, these people have to make certain adjustments to their environment. What might some of these adjustments be?



If a person who is colour-blind were to look at the picture on this page, that person would most likely see the colours as those shown in the picture on the next page. Why do you think this would be so?



Using your ears

Close your eyes for a moment and listen to all the sounds around you. What things did you hear? Did you hear people talking? Or people walking? What other things about your environment could you discover by using only your ears?

You probably know that a sound is made when something vibrates. And when something vibrates, it causes the air around it to vibrate. These sound vibrations are then picked up by your ears.

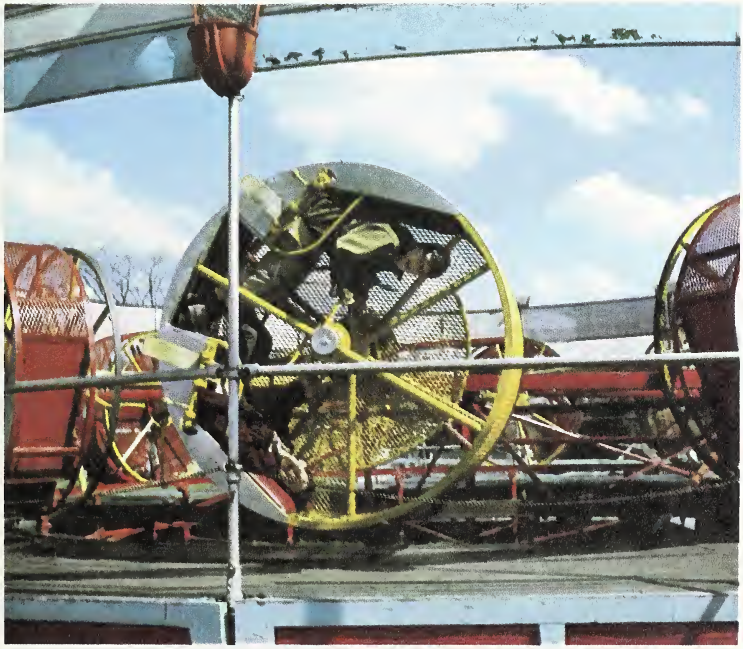
Within each of your ears is an eardrum and three small bones. These things carry sound vibrations to sensory neurons in each of your ears. These neurons are found in a part of your ear called the *cochlea* [KOH-klee-uh]. Some of these neurons pick up low sounds. Other such neurons pick up high sounds.

Some people are not able to hear high sounds or low sounds as well as other people. Why might this be so?

There is another way in which hearing differs among people. You know that some sounds are pleasant to you and some are not. This is true with most people. What are some sounds that are pleasant to you? What are some sounds that are not pleasant to you? Why do you think some sounds are pleasant to some people but not pleasant to other people?

Besides the sensory neurons which pick up sound vibrations, there are other sensory neurons in your ears. These neurons are important to you in another way. Have you ever ridden a merry-go-round? Or perhaps turned around in a circle very fast? If so, you know that afterward you may feel dizzy. Within each of your ears are certain sensory neurons that help control your *sense of balance*. These neurons are found in parts of your ear called the *semicircular canals*. The neurons within your semicircular canals constantly pick up changes in the position of your body.

Sometimes people get an infection in their semicircular canals. This often keeps the sensory neurons from working properly. How might this affect such people?



Using your skin

Have you ever scratched your arm on something sharp? Or have you ever put your hand into some very cold water? If so, you know that your skin collects different kinds of information about your environment. This is because there are many different kinds of sensory neurons in your skin. What are some kinds of information your skin collects about your environment?

Touch. Suppose you have some things such as sandpaper, cotton, coins, and tape. Let's suppose, too, that you are blindfolded. You know that you probably can tell these things from one another by merely touching them. What are some other things you think you can identify by using only your sense of touch? Do you think it is important to have a sense of touch? Why or why not?

Within your skin are certain sensory neurons that are sensitive to touch. Some parts of your body, such as your fingers, are more sensitive to touch than others. Why do you think this is so? What other parts of your body are very sensitive to touch?

FINDING OUT

Which parts of the body are more sensitive to touch than others?

You will need: hairpin or paper clip bent into a U-shape, pencil, paper, ruler, blindfold

- Have a partner put on the blindfold. Then have your partner hold out a hand, palm up.
- Spread apart the tips of the hairpin. Touch both tips lightly against the palm of your partner's hand. Be sure the tips touch at the same time.
- Ask your partner how many tips of the hairpin your partner feels. Be sure sometimes to touch your partner's palm with only one tip so that you know your partner is not just guessing.
- Squeeze the tips of the hairpin a little closer together. Touch your partner's palm again. Keep doing this until your partner can no longer tell whether you are touching the palm with one tip or two tips.
- Measure the distance between the two tips with the ruler. Write down this distance.
- Try other places on your partner's skin such as a finger, forearm, back of hand, forehead, back of neck, and lips. Keep squeezing the tips of the hairpin together until your partner cannot tell the difference between being touched with one tip or with two tips.
- Measure the distance between the two tips. Write down this distance.

Which place on your partner's skin was most sensitive to touch? Least sensitive to touch?
Why do you think some places are more sensitive than others?

Heat and cold. Besides sensory neurons which are sensitive to touch, you also have other sensory neurons in your skin. Some of these neurons are sensitive to heat. Others are sensitive to cold. These neurons are somewhat different from the neurons which are sensitive to touch. For example, when you take a bath, the water may feel quite warm to you at first. But within a minute or so, the water does not feel as warm as it did. This is because the heat-sensitive neurons have lost some of the sensitivity they first had. When this happens, you probably think of this as getting "used to" the temperature of the water.

Your cold-sensitive neurons act the same as your heat-sensitive neurons. When might your cold-sensitive neurons lose some of their sensitivity?

What are these boys discovering about their environment through sensory neurons in their skin?

Pain. Have you ever cut yourself? Or have you ever bumped into something and got a bruise? If so, you know that these kinds of things hurt. They hurt because of pain-sensitive neurons in your skin. Being able to feel pain is very important to people. Why do you think it is important for people to be able to feel pain?

Using your nose

Stop for a moment and think of some foods you can recognize by using only your sense of smell. What are some of these foods? In what other ways do you think your ability to smell is important to you?

Your nose, like other sense organs, has sensory neurons in it. These neurons, of course, are sensitive to odours. Sometimes when you have a cold, you cannot smell as well as you usually do. Why do you think this is so?

There are probably many odours which are pleasant to you. What might some of these odours be? There are also odours which warn you of danger. What might some of these odours be? Why else might it be important to be able to smell things?

Using your tongue

Have you ever noticed that babies try to put almost everything they touch into their mouth? This is a normal thing for babies to do. They are simply trying to find out about things in their environment by using their sense of taste!

For You to Think About

As you know, your sense organs help you in many ways. Because of this, it is important to protect all of your sense organs from injury and from disease. What can you do to help protect your sense organs?

Your tongue is your sense organ for taste. Your tongue has sensory neurons in it called *taste buds*. Your taste buds enable you to taste the foods you eat. This is because your taste buds are sensitive to chemicals in the foods you eat. What are some foods you like the taste of? What are some foods you do not like the taste of? Why do you think people's tastes for foods differ?

Have you ever eaten something which is very cold, such as ice cream? Or have you ever eaten something so hot that it burned your tongue? If so, you probably know that if you were to eat something else right away, you most likely would not be able to taste it. Why do you suppose this is so? Why do you think it is important to be able to taste things?

FINDING OUT

How can you "fool" your sense of taste?

You will need: small pieces of onion, apple, raw potato, blindfold

- Put on the blindfold, and hold your nose shut.
- Have a partner put some pieces of the onion, apple, and potato (one at a time) in your mouth.
- Tell your partner what you think you tasted. Have your partner keep a list of what you think you tasted and what you actually tasted.
- Try tasting five pieces of each food mentioned above.

How many pieces of food did you guess right?

- Now take your fingers away from your nose. Try tasting five more pieces of each food.

How many pieces of food did you guess right this time? Do you think your sense of smell is important to your sense of taste? Why or why not?

A Second Look

1. What kinds of information do the rods and cones in your eyes collect about your environment?
2. In what ways are sensory neurons in your ears important to you?
3. What kinds of information about things in your environment does your skin collect?
4. Why is it important to be able to smell things?

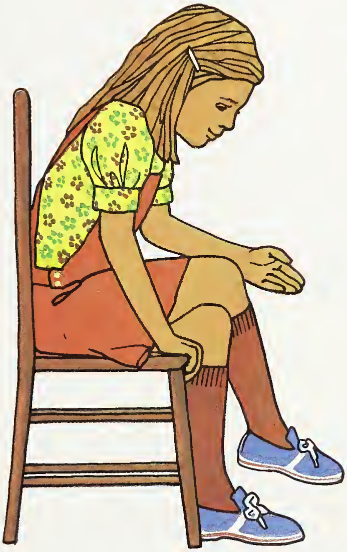
2 Reacting to your environment

Have you ever noticed that you blink your eyes when something, such as a fly, comes close to them, or that you pull your hand away quickly from something hot, such as a stove? Everyone reacts to these kinds of things in much the same way. Why do you think this is so?

Reacting without thinking

You have many reactions such as those mentioned above. These kinds of reactions are called *simple reflexes* [REE-FLEHKS-uhz]. Most simple reflexes are reactions your body makes to protect itself. That is, you blink your eyes when something, such as a bug, comes close to them. This may keep the bug from getting into your eyes. Also, you pull your hand away from something which is hot. This may keep you from getting a bad burn.

But you never had to learn these reflexes, nor do you ever have to think about what to do in these situations. In fact, you cannot control your simple reflexes. You are born with reflexes such as these. What are some other simple reflexes you know of? What do you think controls such reflexes? Do you think that simple reflexes are important to you? Why or why not?



FINDING OUT

How well does your "knee jerk" work?

You will need: chair

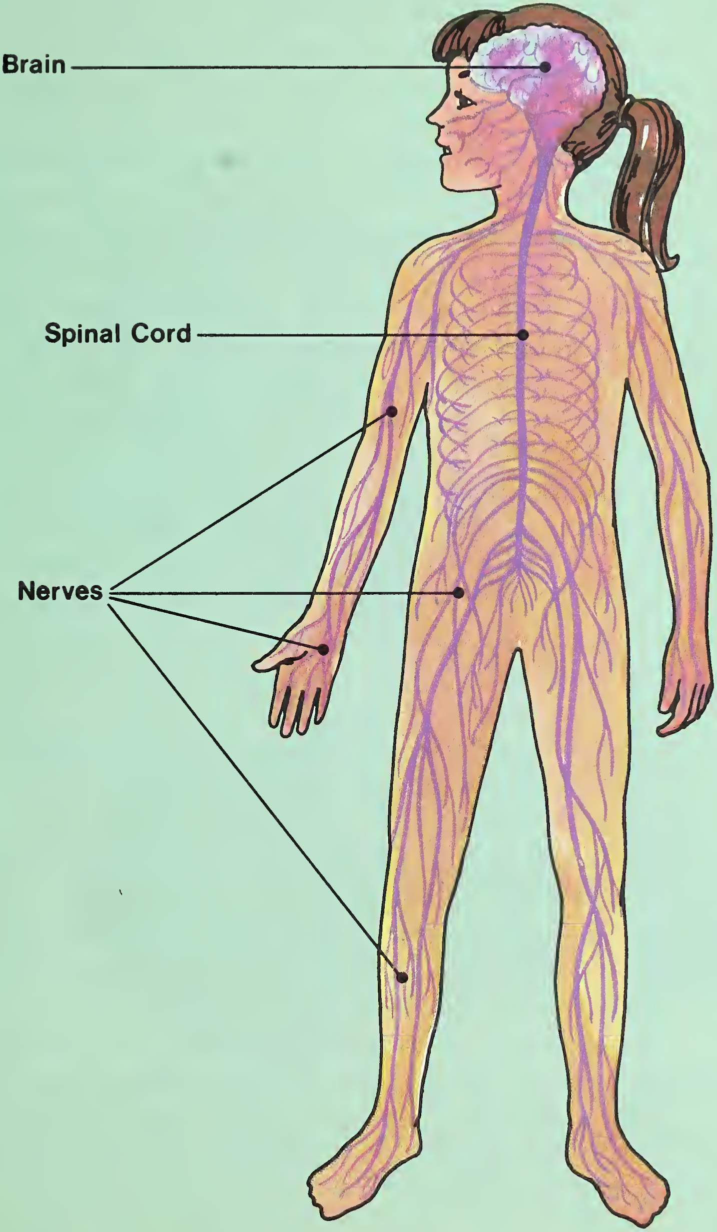
- Sit down on a chair and cross your legs.
- Gently strike your leg just below your kneecap with your hand as shown. Keep doing this until you find the place that makes your knee jerk when it is struck.
- Repeat this, but try to keep your knee from reacting as before.

Do you think that the "knee jerk" is a simple reflex? Why or why not?

Do you think that sneezing and crying are simple reflexes? Why or why not?

Your nervous system

You probably know that you have many different systems in your body. One such system is called the *nervous* [NUR-vuhs] *system.* It is made up of *nerves,* the *spinal* [SPYN-uhl] *cord,* and the *brain.* One thing the nervous system does is control your simple reflexes. Therefore, it enables you to react to your environment.

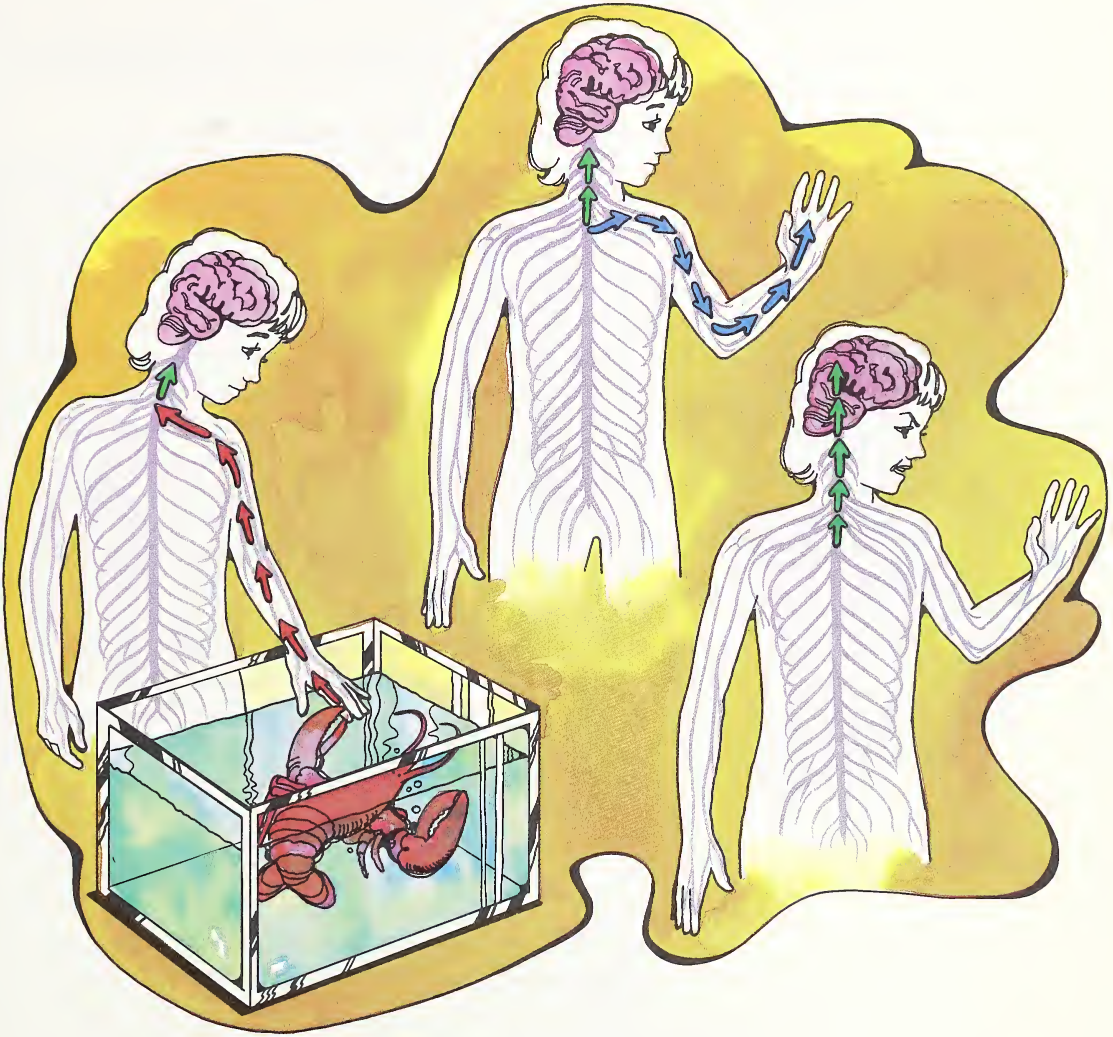

Brain
Spinal Cord
Nerves

As said before, when something comes close to your eyes, you blink. But before you blink, many things take place within your nervous system. For example, the sensory neurons in your eyes pick up the image of something coming close to your eyes. Then your sensory neurons change this information into *impulses* [IHM-PUHLS-uhz], or waves of energy. These impulses then travel along *sensory nerves* to your brain. It is only after these impulses reach your brain that you actually "see" something coming close to your eyes. At this point, your brain sends impulses along other nerves, called *motor nerves*. These nerves carry impulses to the muscles in your eyelids. This causes you to blink your eyes.

There is something very interesting about the way simple reflexes work. Think about the reflex of pulling your hand away from something which is hot. Sometimes you might pull your hand away before you "feel" the heat! This happens because of the way the impulses travel. When your hand touches the hot object, impulses travel from your hand to your spinal cord along sensory nerves. Your spinal cord then sends impulses along motor nerves to muscles in your arm and hand. This causes you to tighten these muscles and, therefore, pull your hand away.

Meanwhile, the spinal cord also sends impulses to the brain along *connecting nerves*. Only after these impulses reach your brain do you actually "feel" the heat. Because your spinal cord sends impulses to the muscles in your arm and hand immediately, you may react to something before your brain knows what has happened! What other reactions might you have which take place before you actually know what has happened?

HOW A SIMPLE REFLEX WORKS



→ Impulses Traveling Along Sensory Nerves

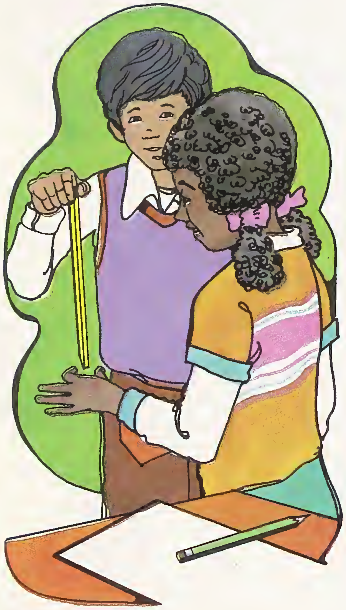
→ Impulses Traveling Along Connecting Nerves

→ Impulses Traveling Along Motor Nerves

FINDING OUT

Which of your senses enables you to react the fastest —sight, hearing, or touch?

You will need: ruler, pencil, paper



- Ask someone to hold a ruler just above your forefinger and thumb. Be sure that the number one on the ruler is closest to the floor. Open your finger and thumb exactly as wide as the ruler's width.
- Then have your partner turn the ruler as shown.
- Have your partner let go of the ruler without warning. Try to catch the ruler with your finger and thumb as soon as you see the ruler drop.

At what number on the ruler did you catch the ruler?

- Do this 3 times. Then write down the average number.
- Now try to catch the ruler again. But this time close your eyes and have your partner say "Now" at the exact time the ruler is released. Do this 3 times.
- Then write down the average number.
- Now try again. This time close your eyes and have your partner touch your head at the exact time the ruler is released. Write down your average number for 3 tries.

Which of your senses enabled you to react the fastest?

- Do the same experiment once again, but have your partner touch your foot exactly when the ruler is released.

Which area of touch, your head or your foot, enabled you to react faster? Why do you think there was a difference in reaction time?

Some interesting simple reflexes

Besides the simple reflexes already mentioned, you have many others. What do you think some of these simple reflexes are?

Adjusting your eyes. Have you ever walked out of a dark movie theater into bright sunlight? If so, you know that it takes a few seconds before you can see very well. Most people say that their eyes need time to "adjust." Yet what has really taken place is a simple reflex which protects your eyes from too much light. Why do you think your eyes need protection from too much light?

Although this simple reflex takes place very quickly, several things happen within the nervous system before your eyes actually adjust. Look for the black spot in the centre of someone's eye. This spot is called the *pupil.* The pupil is an opening through which light enters the eye. Now look for the coloured part of someone's eye. This part is called the *iris.* The iris is a muscle which changes size according to the amount of light entering the pupil. For example, when you are outside on a sunny day, there is a great deal of light entering the pupil.

Sometimes too much light might enter the pupil. When this happens, the sensory neurons send impulses to the brain. The brain then sends impulses to the iris causing it to become larger. This makes the pupil smaller. So, the amount of light entering the pupil is reduced.

What do you suppose happens to the iris when there is not enough light entering the pupil? How might a person's sight be affected if the iris did not work properly?

Yawning. Have you ever been sitting in a warm, stuffy room with a group of people? If so, you know that in a little while people may begin to yawn. There are many reasons given for why people yawn. One reason is that people are bored. Why else might people yawn?

Yawning is also a simple reflex. Although you can hold your mouth shut, you cannot stop the stretching of your neck and throat muscles. Nor can you stop yourself from taking a deep breath.

You probably know that your body takes in oxygen and gives off carbon dioxide. When there is too much carbon dioxide in your blood, a center within your brain sends impulses along motor nerves to certain muscles. This causes you to breathe and sometimes causes you to yawn. It is thought that you yawn because you need to breathe. But it is also thought that you yawn because the slight exercising of muscles in your neck and throat increases the circulation of blood to your brain. Why do you think this is important?

Sweating. Have you ever noticed that on a very hot day you sweat? Sweating is a simple reflex which protects your body from becoming too warm.

Within your brain is a certain centre which keeps the temperature of your body at about 37°C. When your body begins to go above its normal temperature, impulses are sent from your brain to sweat glands in your skin. These glands then produce sweat. As sweat evaporates from your skin, your body cools. Why do you think it is important that your body does not become too warm?

Exploring on Your Own

You have other simple reflexes besides those already mentioned. See if you can find out what some of these other simple reflexes are. Compare your answers with those of a classmate.

Shivering. You probably know that when you get cold, your body may shiver. Shivering is a simple reflex which protects your body from becoming too cold. When your body begins to go below its normal temperature, the brain sends impulses along motor nerves to muscles throughout your body. These impulses cause the muscles to tighten and relax very quickly, or shiver. As a result, the muscles build up a small amount of heat. Why do you think it is important that your body does not become too cold?

Conditioned reflexes

Have you ever come home from school and smelled your favourite meal being cooked? If so, you know your mouth probably began to "water." But suppose you come home from school and smell some food cooking that you have never tasted before. You may not have the same reaction to this smell as you would have to the smell of your favourite meal. Why might this be so?

Reactions such as your mouth watering are called *conditioned reflexes*. Conditioned reflexes are different from simple reflexes in that conditioned reflexes are learned. For example, just smelling something that you know tastes good can cause your mouth to water.

Suppose someone yells, "Look out!" Your immediate reaction would be to move even though you do not know why. Or suppose someone says, "Don't touch that—it's hot!" Your immediate reaction would be to pull your hand away from whatever you were about to touch. Such reactions are also examples of conditioned reflexes. What are some other examples of conditioned reflexes you know of? Why are they important?

Suppose these foods were on a table in front of you. What things could you discover about these foods by using your senses? What conditioned reflexes might these foods bring about in you?

A Second Look

1. What is a simple reflex, and what are some examples of simple reflexes?
2. What parts of your body make up your nervous system?
3. What are impulses, and why are they important?
4. What is a conditioned reflex, and what are some examples of conditioned reflexes?

3 Adapting to your environment

As you know, your nervous system is important because it controls your reflexes. But your nervous system is also important because it enables you to learn about your environment. Learning enables you to *adapt*, or adjust, to your environment. For example, when you walk up to a street corner where there is a traffic light, you know when it is safe to cross the street and when it is not. This, of course, you have learned. And because you have learned about traffic lights and traffic, you might adapt to this part of your environment by not walking into a street at an unsafe time. How else might you adapt to such a situation?

Do you think that adapting to your environment is important? Why or why not?

What are some ways you learn?

As you know, learning enables you to adapt to your environment. And there are many ways in which people learn.

Learning by trial and error. Suppose you are shopping in a store you have never been in before. And suppose you are looking for one certain thing. If so, you know that you probably will have to walk up and down most of the aisles before you find what you want.

But once you find the item you want, you most likely will remember where it is the next time you want to buy the same kind of thing. This kind of learning is called *trial-and-error* learning. You probably have learned many things by trial and error. What are some things you have learned in this way? How has learning these things helped you in adapting to your environment?

Do you think that learning to ride a bicycle is done by trial and error? Why or why not?

Learning by repetition. Do you remember when you were learning to tie your shoelaces or perhaps button a blouse or a shirt? If so, you know that you had to practice these things a few times before you could do them very well. But now you probably can do these things without even thinking about doing them. In other words, you have formed certain habits. Learning to do things in this way is called learning by *repetition* [REHP-uh-TIHSH-uhn]. How has learning these things helped you adapt to your environment?

There are many other things you learn by repetition. What might some of these things be? How has learning these things helped you adapt to your environment?

FINDING OUT

How can you show that writing is a habit?

You will need: paper, pencil

- Give a partner a pencil and a piece of paper. Ask your partner to write down the following sentence as you read it out loud. "At this time, that is interesting to think about."
- Now read the sentence to your partner again, but this time ask your partner to write the sentence without crossing the "t's" and dotting the "i's."
- Now trade places with your partner, and have your partner read the sentence for you while you write.

Did you and your partner find it hard to write the sentence without crossing the "t's" and dotting the "i's"? If so, why?

Learning by organizing. Have you ever tried to learn something which did not make sense to you? For example, try memorizing the words listed below. Do not look at the words for more than one minute. Write down all the words you remember on a piece of paper. How many words did you remember?

1. under
2. gone
3. she
4. still
5. she
6. is
7. a
8. there
9. woman
10. hill
11. if
12. old
13. who
14. an
15. lived
16. was
17. there
18. not
19. lives

Now put the words in the following order: 8, 16, 14, 12, 9, 13, 15, 1, 7, 10, 11, 3, 6, 18, 2, 5, 19, 17, 4. Look at the words for another minute. Write down all the words you remember this time. How many words did you remember? Do you think that *organizing* things so that they make sense can help you learn? Why or why not?

When has organizing things been helpful to you in learning something? How has this been helpful in adapting to your environment?

Exploring on Your Own

As you may know, memory is an important part of learning. See if you can find out in what ways memory is an important part of learning.

Learning by association. You most likely have burned a finger or a hand by touching something hot, such as a hot stove or a burning match. And although you are born with the simple reflex of pulling your finger or your hand away from such things, you also learn from this kind of experience. That is, you learn that anything which is hot can burn you. This kind of learning is called learning by *association* [uh-SOH-see-AY-shuhn].

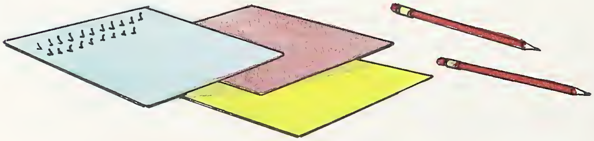
FINDING OUT

How can you show that people learn some things by association?

You will need: paper and pencils for 2 or 3 people

- Give each of your partners a pencil and a sheet of paper. Tell your partners you want them to make a check mark on their paper each time you say the word "Check."
- Say the word "Check" about 15 times very quickly. About halfway through, start snapping your fingers at the same time you say "Check."
- After about 15 times, stop saying the word "Check," but continue snapping your fingers.

Did your partners continue to make check marks on their paper after you stopped saying "Check"? If so, why do you think they did?



Do you know someone who is afraid of cats or dogs? If so, this person most likely developed this fear through association. How might this have happened? What are some things you have learned by association? How has learning these things helped you adapt to your environment?

Learning by reasoning. People have the ability to reason. Because of this, they often use *reasoning* to help solve certain problems. Suppose you want to go to a summer camp, but you have never been to one before. And suppose you know what kinds of activities you like best. If you were in this situation, you could write down a list of your favourite activities. Then you could look up the name and address of each camp listed in a telephone book. Finally you could write to each camp and ask what activities are offered. By comparing your list of favourite activities with the list you receive from each camp, you could make a decision as to which camp you want to go to.

In doing something such as this, you are using reasoning to solve a problem. What are some problems you have solved by using reasoning? How has solving these problems helped you in adapting to your environment?

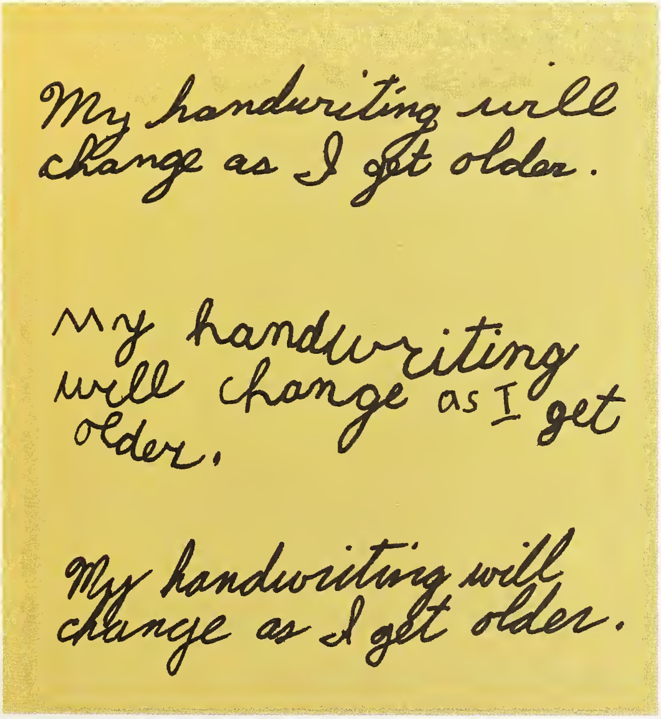
Chess and many other games are learned by using reasoning. What are some games you play that you learned by using reasoning?

What are some things that affect learning?

As you know, learning enables people to adapt to their environment. But there are many things which can affect learning and, therefore, can affect how people adapt to their environment. What things do you think might affect learning?

Your age. Have you ever watched a baby learning to walk? If so, you know that a baby begins by holding on to someone or something. Then the baby learns to take a step or two alone. Finally, the baby learns to walk without any help. All babies do not learn to walk at the same time. Some may begin walking when they are eight or nine months old. Others may begin walking when they are a year or a year and a half old. There are these differences because people *mature* physically, or develop physically, at different speeds.

There are many things which people learn only after they are physically mature enough to do these things. For example, when you first began to write, you may remember that your "letters" were very big and that some may not have been quite right. This happened because you were not physically mature enough to make small and accurate movements with your fingers. In time this changed and so did your handwriting. These kinds of things are a part of normal growth. What are some things you can do now that you could not do a few years ago? How are these things helpful in adapting to your environment?



My handwriting will
change as I get older.

My handwriting
will change as I get
older.

My handwriting will
change as I get older.

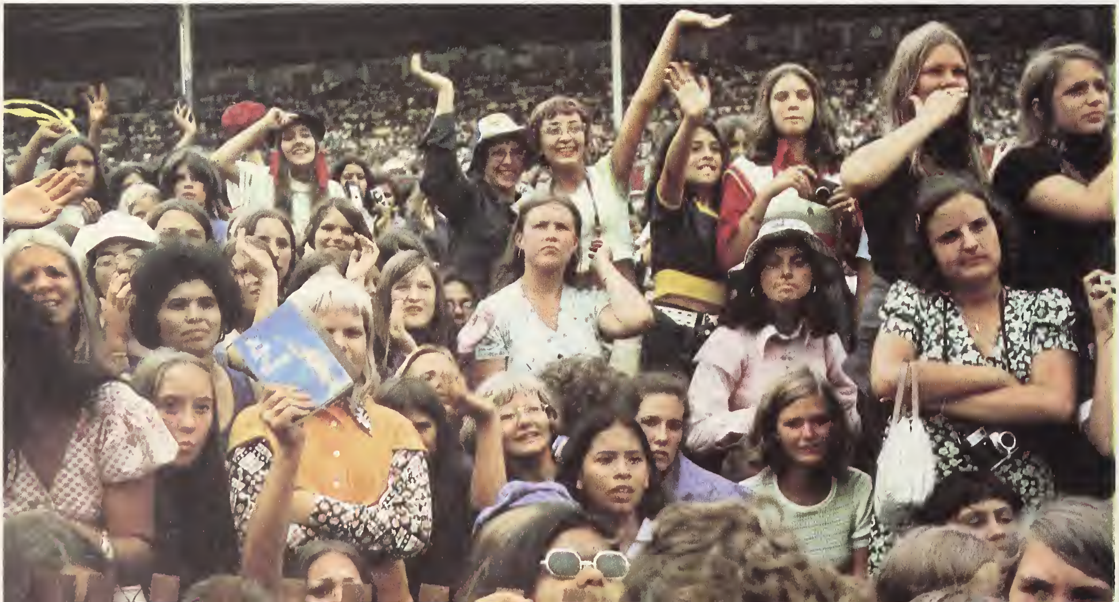
These sentences were written by a second grader, a fifth grader, and a seventh grader. Can you tell which sentence was written by each pupil? If so, how can you tell?

Your perceptions. Have you watched a ball game in which your team was ahead and there were only a few seconds left in the game? If so, you know that you felt pretty happy. But how do you think the people whose team was behind felt?

People often *perceive* [pur-SEEV], or look at, the same things differently. And how people perceive things affects how they learn. For example, suppose you and a friend go to a museum. And suppose you are interested in looking at the things in the museum. But your friend is interested in watching the people that visit the museum. How might each of your perceptions of the museum affect what you learned at the museum?

What are some other things you have perceived differently from others? How might knowing that people sometimes perceive things differently from others help you understand people? How might understanding people help you adapt to your environment?

Are these people perceiving the event in the same way? Why or why not?



Your self-concept. You know that there are some people who see themselves as being good at doing many things. There are also some people who see themselves as not being good at doing many things. The mental image that people have of themselves is called their *self-concept.*

A person's self-concept often affects the ways in which that person learns. For example, suppose you see yourself as someone who is a very good singer. How might this self-concept affect your learning of a new song? Now suppose you see yourself as someone who is not very good at memorizing things. How might this self-concept affect your learning of a part for a school play?

Think about your self-concept. In what ways has it affected your ability to learn certain things?

For You to Think About

Do you think it is possible to change your self-concept? If so, how might you go about doing this?

Most people feel they are good at doing certain things. Why do you think this is important? What are some things you feel you are good at?

Your emotions. Have you ever had a day when everything seemed to go right for you? If so, you probably were very happy. But how did you feel on a day when everything seemed to go wrong for you? Everyone experiences many different *emotions,* or feelings. These emotions can affect your learning. For example, suppose some people are coming to visit your family for the evening. And suppose you really like these people. How might looking forward to this visit affect your learning at school that day? What are some other ways in which emotions might affect your learning and therefore your ability to adapt to your environment?

How might the emotions of these people affect their ability to adapt to their environment?

A Second Look

1. What are some ways you learn?
2. What are some things which can affect learning?
3. Why is learning important to people?

Workers Who Use Science

As you know, there are many things that can affect how people learn and, therefore, how they adapt to their environment. Because of this, some people study the ways in which people learn and the things which can affect their learning.

Some of the people who study learning are called *educational psychologists* [sy-KOL-uh-juhsts]. An educational psychologist may make up tests to help discover things which affect how a person learns in school. Or such a psychologist might make up tests that are helpful in finding out what jobs a person might be good at.

There are other people who give tests such as those mentioned above. These people are called *psychometrists* [sy-KOM-uh-truhsts]. A psychometrist not only gives tests but also uses the information from these tests to help find out what things might be affecting a person's ability to learn. This information can also be used to help people learn more easily.

There are still other people who study how people learn. Such people include *school psychologists* and *counseling psychologists*. To find out about the work of these people, find the answers to these questions:

How might a school psychologist help people learn?
How might a counseling psychologist help people learn?

Along with using sources of your own, writing to the following source may be helpful: Canadian Psychological Association, Department of Psychology, University of Toronto, Toronto, Ontario M5S 1A1.

The educational psychologist (left) is studying the results of tests given to pupils by the psychometrist (right). Have you ever taken such tests? If so, when?

Reviewing the Main Ideas

People discover things about their environment by using their senses.

The sense organs include the eyes, ears, skin, nose, and tongue.

The nervous system is made up of nerves, the spinal cord, and the brain.

Information collected by the sense organs reaches the brain by means of the nerves and the spinal cord.

People often react to things in their environment by means of reflexes.

Learning is important to people in adapting to their environment.

There are many ways in which people learn.

There are many things that can affect how a person learns.

Reading About Science

"Learning." *The World Book Encyclopedia,* Volume 12. Don Mills, Ontario: Addison-Wesley (Canada) Ltd., 1974.

Silverstein, Alvin, and Silverstein, Virginia. *Sense Organs: Our Link with the World.* Scarborough, Ontario: Prentice-Hall of Canada Ltd., 1970.

Zim, Herbert C. *Your Brain and How It Works.* Agincourt, Ontario: Gage Publishing Limited, 1972.

Testing for Understanding

Ideas to Check

On your paper write *T* for each sentence below that is true. Write *F* for each sentence that is false.

1. The rods in your eyes enable you to see at night.
2. Your taste buds are sensitive to the chemicals in foods you eat.
3. Everything you discover about your environment you discover through your sense organs.
4. Sensory neurons change information about your environment into impulses.
5. Simple reflexes are reflexes you can control.
6. Your self-concept has little to do with how you adapt to your environment.

Words to Use

Write on your paper the word or words that best fit in each blank below. Choose from these words: *motor nerves, semicircular canals, conditioned reflex, sensory nerves, simple reflex, cochlea, trial and error, association.*

1. Sensory neurons in your ____ enable you to hear.
2. Sensory neurons in your ____ help you keep your balance.
3. ____ carry impulses from your senses to your spinal cord and brain.
4. ____ carry impulses from your brain and your spinal cord to your muscles.
5. When someone yells, "Look out!" your reaction would most likely be a ____.

Having Fun with Science

Purple Cookies!

Get some food colouring and a recipe for making cookies. Make the cookie dough, then separate it into 4 or 5 different bowls. Add a different colour of food colouring to each bowl of cookie dough. Bake the cookies. Offer them to some friends. Which colour of cookies was eaten first? Last? Do you think that sight is important to people when choosing the food they want to eat? Why or why not?

I've Got (hic) the Hiccups!

Most people have experienced the simple reflex of hiccuping. Because of this, there are many suggestions for stopping the hiccups. One suggestion is to hold your breath for as long as you can. What other suggestions have you heard of? Try finding out which suggestions actually work. You might want to ask a doctor about such suggestions.

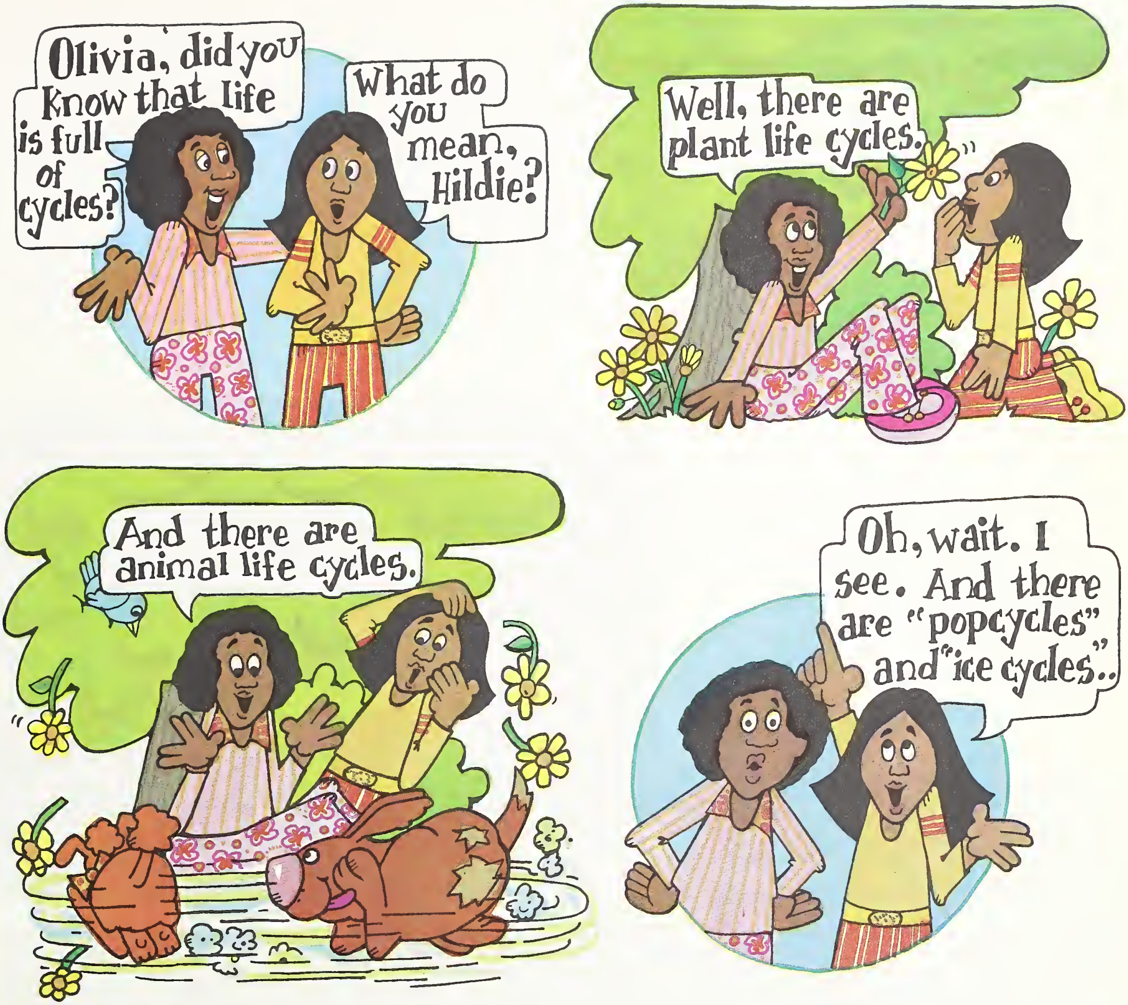
How's Your Reasoning?

1. A woman and a child are walking down the street. The woman is the child's mother, but the child is not the woman's daughter. How can this be so?

2. There were two sisters who had neither seen each other nor had seen a picture of each other for more than 30 years. Yet one day when they accidentally passed each other in a train station, they recognized each other immediately. How could this be so?

2 Plant and Animal Life Cycles

1 The stages of a life cycle
2 Some interesting plant life cycles
3 Some interesting animal life cycles


Olivia, did you know that life is full of cycles?
What do you mean, Hildie?
Well, there are plant life cycles.
And there are animal life cycles.
Oh, wait. I see. And there are "popcycles" and "ice cycles."

Do you think Olivia understood what a life cycle is? Why do you think so?

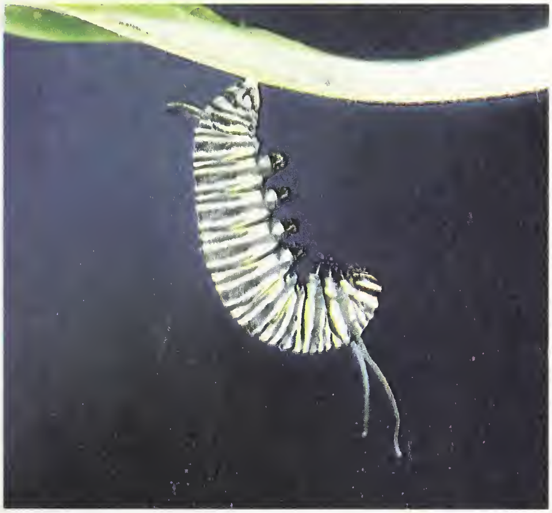
What do you think is meant by a plant life cycle and an animal life cycle?

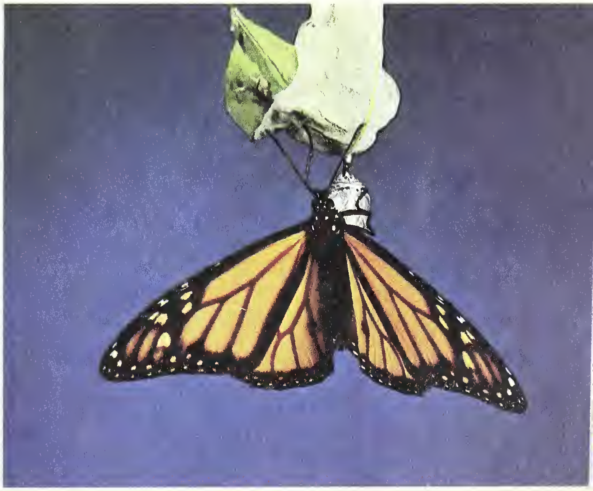
1 The stages of a life cycle

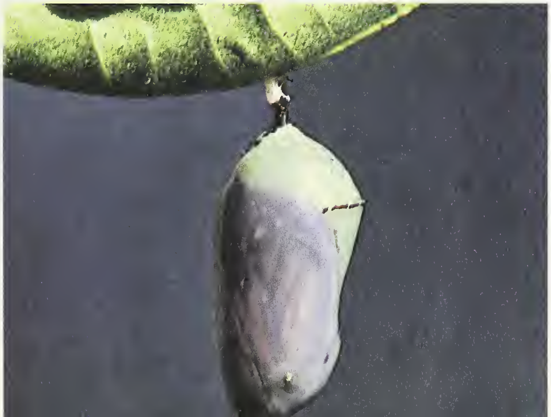
Baby. Teenager. Adult. You probably know that these are three of the many stages that people pass through as they grow. All living things pass through different stages as they grow. What are some plants and animals you have seen pass through different stages?

Generally, the time from the beginning of a plant or an animal's first stage of growth to the end of its last stage of growth is called a *life cycle*. During their

life cycle, plants and animals change as they grow. Some plants and animals change more than others. For example, an apple tree changes more than a violet plant during its life cycle. A butterfly changes more than a chicken. The pictures on pages 50 and 51 show some stages of the life cycle of a plant and the life cycle of an animal. In what ways do these living things change during their life cycle?

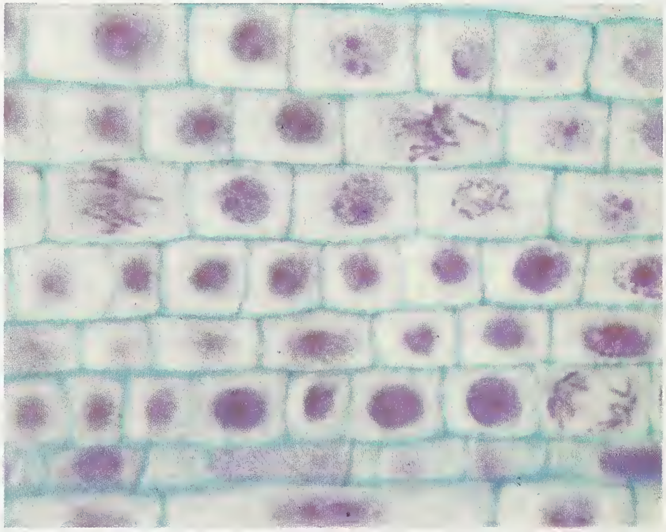






The beginning of a life cycle

The first stage that plants and animals pass through begins when they first start to grow. Plants and animals most often start to grow from a single *cell*. Cells are tiny units of living matter that make up the body of every living thing. The body of some living things is made up of only one cell. But the body of many other living things is made up of millions of cells. How do you think a single cell grows to be a plant or an animal made up of millions of cells?



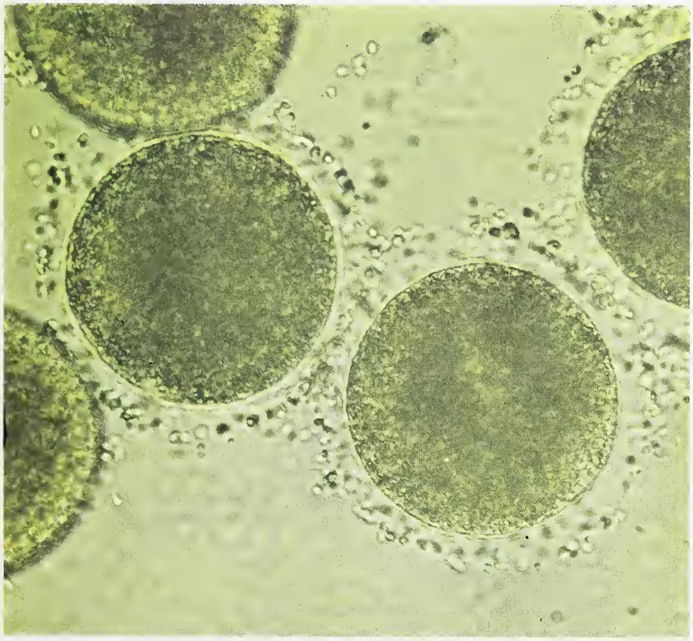
Most cells cannot be seen without the aid of a microscope. What things do you notice about these onion cells in this picture taken through a microscope?

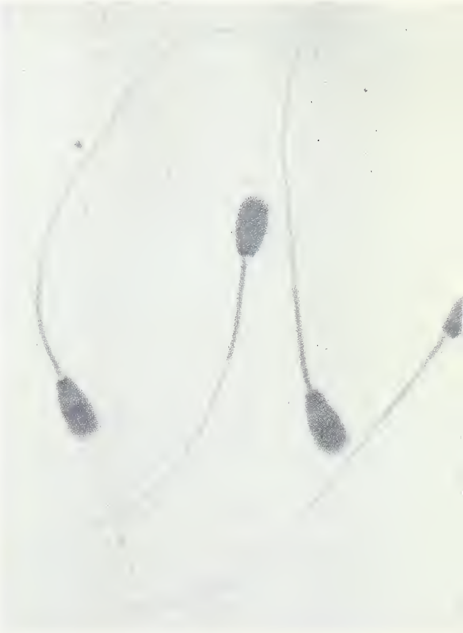
A new cell is formed. A cell which is the beginning of a new plant or animal is the result of *reproduction* [REE-pruh-DUHK-shuhn]. Reproduction is the means by which every living thing produces new living things that are like itself.

There are different kinds of reproduction. In one kind of reproduction, a cell which is the beginning of a new living thing is formed from another cell. This takes place in one-celled living things, such as the *amoeba* [uh-MEE-buh]. An amoeba divides into two equal cells. Each of these cells is a new amoeba.

In another kind of reproduction, a cell which is the beginning of a new living thing is formed when two special cells join together. These special cells are called *sex cells*. One of these cells is a female cell. It is called an *egg cell*. The other cell is a male cell. It is known as a *sperm cell*. The sperm cells of many living things have tails. These tails help the sperm cells move. Why do you think it is important that sperm cells move?

Below left: Egg cells of a sea urchin. Below: Sperm cells of a bull. Unlike sperm cells, egg cells have no tails. Why do you think egg cells need no tails?

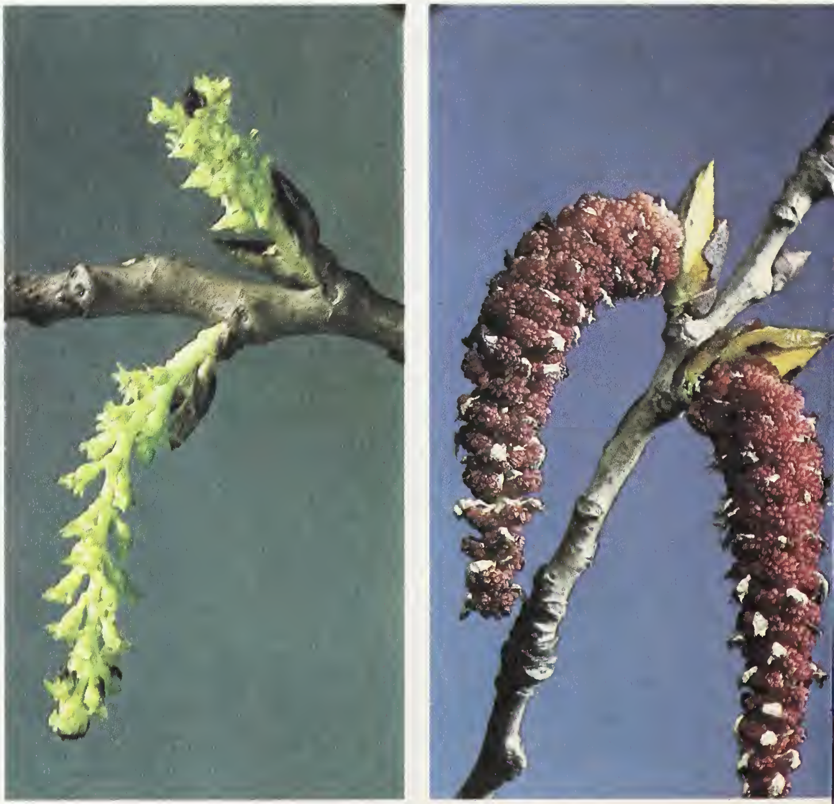




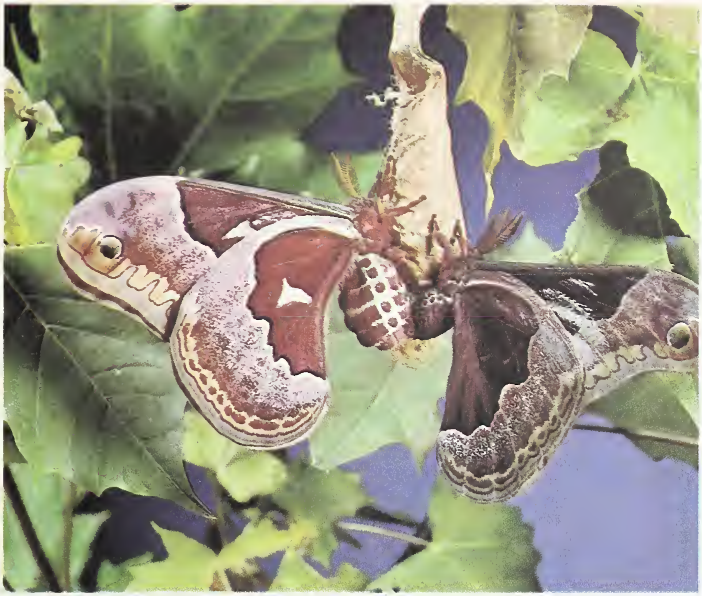
Exploring on Your Own

In addition to those mentioned, some other kinds of reproduction are *budding, regeneration,* and *vegetative propagation.* See if you can find out what kinds of plants or animals use these kinds of reproduction.

Egg cells and sperm cells are formed in the body of parent plants and animals. Plants and animals which have sperm cells are known as male. Plants and animals which have egg cells are called female. However, there are many plants and animals that have both kinds of sex cells. For example, daisies are flowers that have both kinds of sex cells. Earthworms are animals that have both kinds of sex cells. The sperm cells and egg cells of these living things are formed in different parts of their body.



Far right: Parts of a female cottonwood tree in which the egg cells are formed. Right: Parts of a male cottonwood tree in which the sperm cells are formed. How are the parts in each picture alike? Different?



You may be able to tell a male moth (right) from a female moth of the same kind (left) by the colour of each moth. What other animals do you know of that you may be able to tell the male from the female by the colour of each animal?

Fertilization. Sex cells carry the characteristics of the parent plants and animals. Because of this, new plants and animals will have some of the characteristics of each parent. Therefore, how a new living thing will grow and what it will look like is decided when a sperm cell and an egg cell join together. This joining is known as *fertilization* [FURT-uhl-uh-ZAY-shuhn].

Fertilization takes place in different ways in different kinds of plants and animals. For instance, the sperm cells and egg cells of most fish meet in the water. The female fish lays thousands of egg cells in the water. The male fish deposits millions of sperm cells in the water just above the egg cells. Then, the sperm cells swim to the egg cells. When a fish sperm cell *fertilizes*, or joins with, a fish egg cell, the new cell that is formed is called an egg.

In fish reproduction, a single sperm cell usually fertilizes a single egg cell. But, many sperm cells and egg cells do not join together. These cells soon die. Why do you think many of the sperm cells and egg cells of fish may not join together?

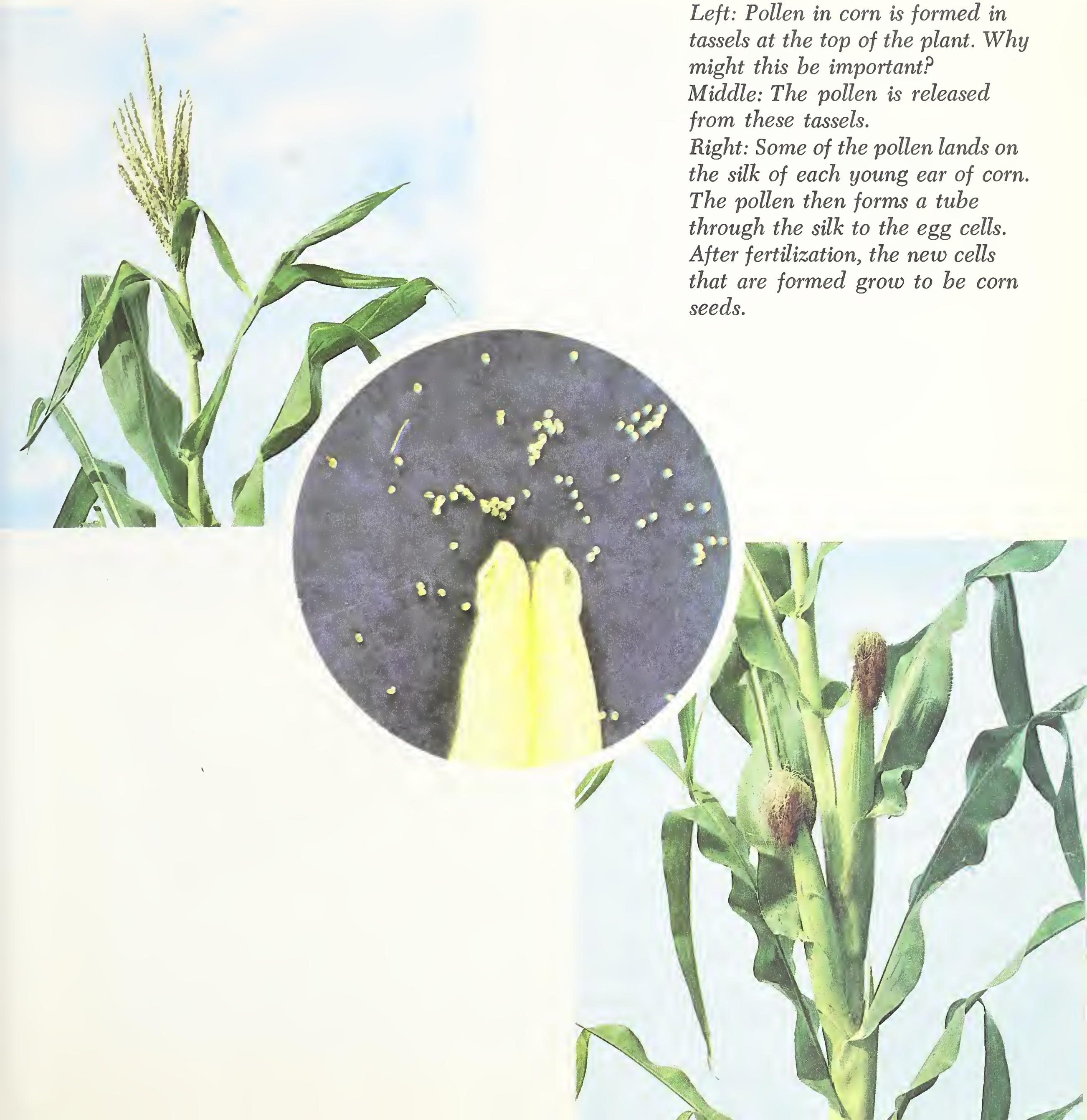
Fertilization in many other animals takes place inside the body of the female. The male animal deposits millions of sperm cells inside the body of the female. Generally, only a few of these sperm cells fertilize egg cells. The sperm cells that do not fertilize an egg cell soon die.

As was said before, both sperm cells and egg cells are formed in the body of many plants. Fertilization takes place inside the part of the plant which holds the egg cells. But first, the sperm cells must reach this part. The wind often carries the sperm cells to this part. They are carried in the form of grains called *pollen*. What other things might carry pollen?

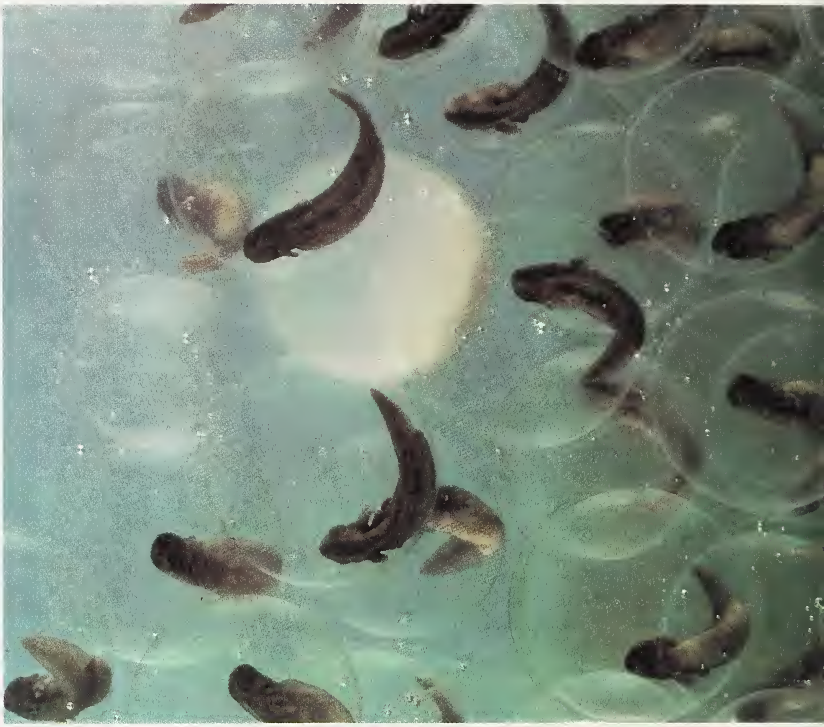
Growing from a single cell. Once a sperm cell and an egg cell join together, the new cell begins to grow. It grows by dividing. First, the cell divides into two equal cells. These cells divide into four equal cells, and so on. Finally, a new living thing is formed.

After the new cell first divides, the growing cells make up an *embryo* [EHM-bree-OH]. Embryos of different kinds of living things may grow in different places. For example, the embryos of many plants, such as dandelions and beans, grow inside the body of the parent plants. As an embryo grows, it becomes part of a *seed*. The embryos of many animals, such as dogs and cats, grow inside the body of the female.

The embryos of most fish grow inside eggs which are in the water. The embryos of many other animals,



Left: Pollen in corn is formed in tassels at the top of the plant. Why might this be important?
Middle: The pollen is released from these tassels.
Right: Some of the pollen lands on the silk of each young ear of corn. The pollen then forms a tube through the silk to the egg cells. After fertilization, the new cells that are formed grow to be corn seeds.



The frog embryos in this picture are about to hatch from their eggs. What do you notice about these embryos?

such as turtles and birds, also grow inside eggs. These eggs, unlike fish eggs, are covered by a shell and leave the body of the females after fertilization. Why do you think a shell around such eggs is important?

In order to grow, an embryo needs air, food, and water. An embryo growing inside an egg that has a shell gets air through the shell. This embryo gets food and water from inside the shell. An embryo growing inside the body of a female plant or animal gets the things it needs from the body of the female. Do you think it is important for a female plant or animal to be healthy when it has an embryo? Why or why not?

FINDING OUT

What does the egg cell of a chicken look like?

You will need: chicken egg, pan or dish

- Crack open the shell of the chicken egg (a chicken egg is an egg cell) over the pan. Let the egg cell fall gently into the pan.
- Find the yolk, or the yellow part, of the egg cell. This part is food for the embryo. (A chicken egg from a store has probably not been fertilized, so you may not see an embryo.)

Why do you think this food is important?

- Find the clear part of the egg cell that surrounds the yolk. This part helps protect a growing chicken embryo.

How do you think the clear part helps protect the embryo?

- In some chicken egg cells you might also find 1 or 2 white, cordlike parts. These parts connect the yolk to a thin lining inside the shell. The cordlike parts help keep the yolk in place. Try finding these cordlike parts.
- Also try to find the thin lining on the inside of the broken shell.

Why do you think the shell is important to a growing chicken embryo?

Youth

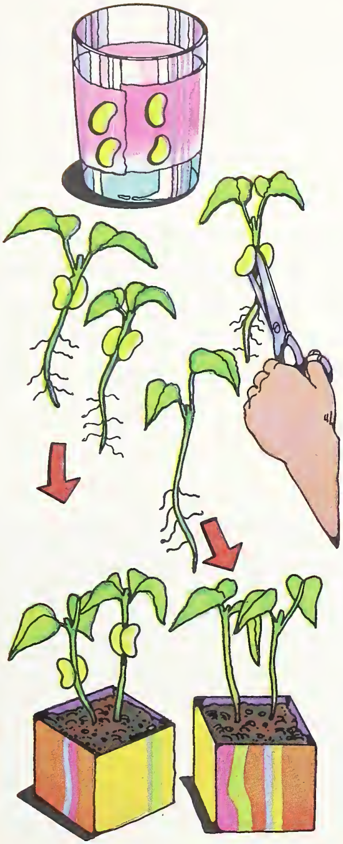
Another stage of the life cycle of a plant or an animal is called *youth*. Youth for many plants begins when the embryo sprouts from its seed. Youth for many animals begins when the embryo hatches from an egg. Youth for an animal embryo which has been growing inside the body of its mother begins when it is born.

As plants and animals grow during youth, the cells of their body continue to divide over and over. For this to happen, the young plants and animals need food. But different kinds of living things get the food they need in different ways. For example, plants which sprout from a seed get the food they need from food stored in the seed. Later, when the leaves of their body grow bigger, the leaves make food for the plant.

FINDING OUT

What happens to young plants when they do not get food from their seed?

You will need: about 4 or 6 seeds (such as lima beans or kidney beans), glass, paper towels, 2 milk cartons, soil, scissors



- Put the seeds (beans are seeds) in the glass to soak overnight.
- The next day, empty the glass. Put some paper towels, the seeds, and some water inside the glass as shown.
- Look at the glass every day to see that there is some water in it.
- When the seeds begin to grow, take the young plants out of the glass.
- Cut off the top of each carton. Fill the cartons with soil.
- Cut off the remaining parts of the seeds from the stem of half of the young plants as shown.
- Plant these plants in one carton. Plant the other young plants in the other carton.
- Place the cartons by a window through which sunlight often shines.
- Keep the soil damp for a week or two.

What happened to the young plants in each carton? Why?

Many animals, such as fish and frogs, can get the food they need by themselves as soon as they hatch. However, many other animals, such as puppies and birds, depend on their parents for food during the first part of youth. What other animals do you know of that can get their food by themselves during the first part of youth? What other animals do you know of that depend on their parents for food during the first part of youth?

Do you think this young opossum depends on its mother for things other than food? If so, what?

Adult and old age

When most living things grow to be full size, they leave youth and enter a stage known as the *adult* stage. During this stage, most plants and animals are able to *reproduce*. That is, they are able to have new plants and animals of their own. What do you think it would be like if no living things lived to be adults?

If a plant or an animal lives long enough, it passes through the adult stage into the stage called *old age*. For some reason, certain cells of the body of a living thing stop growing during this stage. Because of this, certain parts of a living thing may stop working as they should. For example, the roots and the leaves of a plant may stop working as they should. The heart and the brain of an animal may stop working as they should. Once these parts stop working, the plant or animal dies. At this point, the plant or animal completes its life cycle. What would it be like if no living things ever completed their life cycle?

A Second Look

1. What is a life cycle?
2. What are some of the stages of a life cycle that many plants and animals pass through?

2 Some interesting plant life cycles

If someone were to ask you what you thought the earth would be like without plants, what would you say? Would you say that the earth would look bare without plants? Would you say that there would be no vegetables, no fruit, or no cereal to eat? Would you say that there would be no food for many animals? What else would you say?

Many people realize that plants are very important. Plants are not only used for food, but they are also used to make things such as clothes and medicine. Many people enjoy growing plants. For these reasons, some people study the life cycle of certain plants. How might knowing about the life cycle of certain plants be helpful to people?

Life cycle of a spore-bearing plant

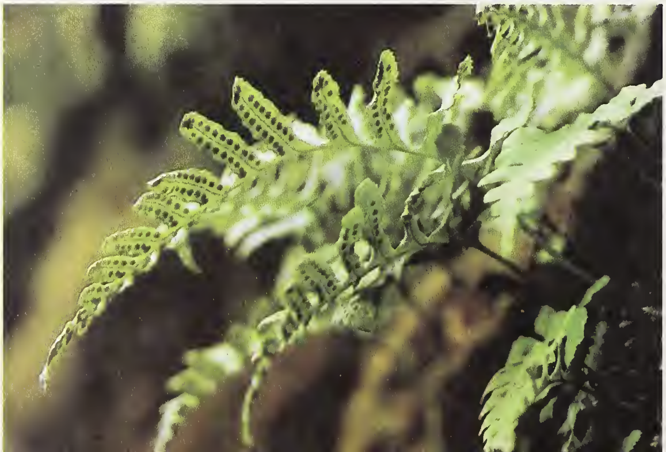
For hundreds of years, people have studied plants. Long ago, people found that some plants are alike in certain ways. People often listed plants which are most alike in groups. One such group is called *spore-bearing plants.* The plants that make up this group are alike in that they begin their life cycle as a single cell known as a *spore.*

Among the spore-bearing plants are the *ferns.* These plants have roots, stems, and large leaves. Most kinds of ferns live in woods that are damp and warm. Have you ever seen a fern? If so, where?

Step one! The life cycle of a fern is very different from the life cycle of many other plants. A fern actually has two main parts to its life cycle. The first part usually begins in the fall of the year. At this time, spores are formed on an adult fern. If you were to look at the bottom side of a fern leaf in the fall, you might see many brown spots. These spots are cases which hold spores. Why do you think it is important that fern spores are held in cases?

Exploring on Your Own

Like most plants, ferns are important in many ways. Try to find out some ways ferns are important. You may do this by looking in reference books under the heading *ferns.*



Sometime after the spores are formed, the cases begin to dry. Once the cases are dry, they open and the spores pop out. Some of the spores fall to the ground. If the ground is damp, these spores begin to grow.

Like other kinds of cells, a spore grows by dividing. Soon, a small flat plant is formed. But there is something unusual about this plant. That is, it does not look like an adult fern!

However, in a few months, sperm cells and egg cells which carry the characteristics of a fern are formed by the small plant. The sperm cells, which are able to move on their own, are formed in one part of the plant. The egg cells, which cannot move by themselves, are formed in another part of the plant.

Step two! At a time when the small plant is damp, the sperm cells swim along the plant to the egg cells. When a sperm cell fertilizes an egg cell, a new cell is formed. The new cell then grows by dividing. The growing embryo gets the food it needs from the small plant. Soon, the embryo grows leaves and becomes a young fern. The leaves of the young fern make food. At this

As a fern grows, its new leaves uncurl. Do you know of any other plants in which new leaves uncurl? If so, what are these plants?

time, the small plant dies. Why do you think it is important that the small plant dies only when the young fern has leaves?

After the small plant dies, the young fern grows even more. Finally, the young fern becomes an adult and is able to grow spores. Eventually, the adult fern becomes old and dies. Why do you think it is important that ferns die after they become old?

FINDING OUT

How can growing moss help you learn about the life cycle of a spore-bearing plant?

You will need: soil, small pieces of charcoal, wide-mouthed glass container, moss

Moss is a spore-bearing plant which has a life cycle similar to that of a fern.

- Line the bottom of the container with the charcoal.
- Fill the container about half full with soil. Carefully plant the moss in the soil.
- Place the container in a shady place.
- Keep the soil damp.
- Watch your moss grow for a few weeks.

What things did you learn about the life cycle of a moss?

Life cycle of a cone-bearing plant

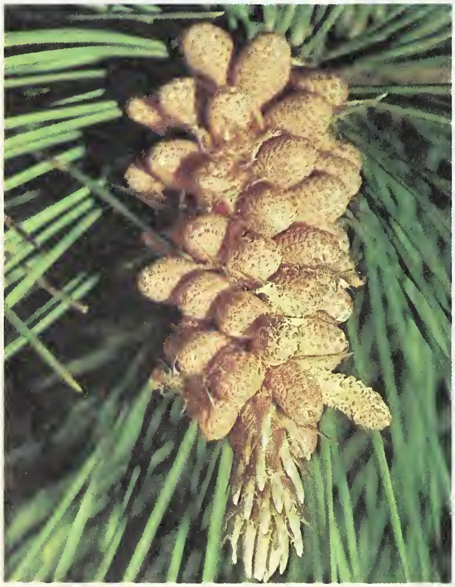
At some time, you may have seen a tree with cones and with needlelike leaves which were green all year long. If so, you saw a tree which is part of a group of plants called *cone-bearing plants.* A common cone-bearing plant is the *pine.*

There are hundreds of kinds of pines. Many of these plants are used by people for lumber and for making paper. People also plant pines for their beauty. Why might it be important for people to know about the life cycle of a pine?

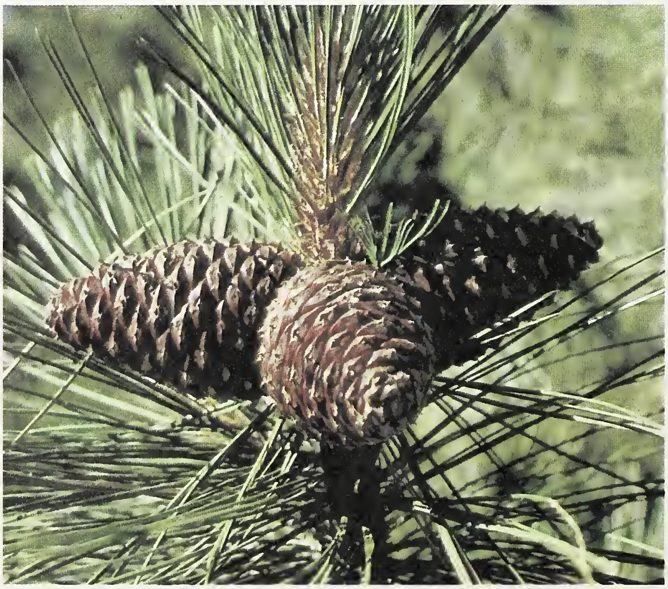
What happens in the cones? Like many other adult plants, most adult pines form both sperm cells and egg cells. The sperm cells of a pine are formed in small cones. These cones, called *male cones,* grow on the upper branches of a pine. The egg cells are formed in larger cones which grow on the lower branches. These cones are called *female cones.* Why do you think it is important that the male cones of a pine grow on higher branches than the female cones?

Sometime after the sperm cells are formed, they are shed in pollen grains from the male cones. Much of the pollen from a pine falls on the female cones of the same pine. However, some of the pollen may be carried by the wind to the female cones of other pines. Do you think all the pollen from the male cones lands on the female cones? Why or why not?

Male Pinecones



Female Pinecones



After pollen lands on a female cone, it is held there by a sticky fluid. The female cone slowly opens. This allows the sperm cells from the pollen to reach the inside of the cone. The sperm cells then form a tube which leads to the egg cells. About a year later, the sperm cells finally reach the egg cells and form new cells.

When a sperm cell and an egg cell join together, the new cell they form begins to grow by dividing. The growing embryo gets the food it needs from the cone around it. After another year, the embryo begins to look like a tiny plant. The embryo is surrounded by food which is formed by part of the female cone. The embryo and the food make up a seed. Why do you think this food is important?

FINDING OUT

What does the inside of some pinecones look like?

You will need: male and female pinecones which have not dried out, knife

- Draw a picture of each cone.
- Using the knife, cut open each cone.
- Look at the inside of each cone. Draw what you see.

How was the inside of each cone different?
Compare your cones with cones from other kinds of pines.
How are the cones alike? How are they different?

What happens outside the cones? Each female pinecone may hold many seeds. At a time of the year when the weather is warm, the female cone opens even more. The seeds inside the cone fall to the ground. Some of the seeds begin to grow soon after they reach the ground. As the embryo inside each of these seeds grows, it uses the food inside the seed. Soon each embryo becomes a young pine with leaves which make food.

After many years, the young pines become adults. The adult pines form cones, and the life cycle of new pines begins. If a pine lives long enough to complete its life cycle, the pine becomes old and then dies. Why might many pines not live long enough to complete their life cycle?

Life cycle of a flowering plant

Along with spore-bearing plants and cone-bearing plants, there is another group of plants. This group is known as *flowering plants.* The plants in this group are different from other plants in that they grow flowers. Some flowering plants that you may know of are *apple trees.* What are some other flowering plants that you know of? Why are flowering plants important to people?

Parts of a flower. There are many kinds of apple trees. But if you have ever seen an apple tree, you may know that adult apple trees grow flowers in the spring. One part of each flower is called the *anther.* This part forms and holds pollen. Another part of each flower forms and holds egg cells. This part is known as the *ovary.* In order for the life cycle of a new apple tree to begin, pollen from an anther must reach still another part of the flower. This part, called the *stigma,* is near the ovary. What other parts of a flower do you know of?

There are several ways that pollen may reach a stigma of an apple blossom. For instance, wind may carry pollen from an anther to a stigma. Certain animals, such as bees, may also carry pollen to a stigma. These animals may catch pollen on their body as they brush against an anther. When the animals brush against a stigma, the pollen sticks to the stigma.

Beginning of a seed. Once pollen reaches the stigma of the same flower or a flower of another apple tree, the pollen begins to grow a tube. This tube leads from the stigma to the ovary. Just before or during the time the tube is growing, each pollen grain divides into two cells. These cells are sperm cells. When the tube reaches

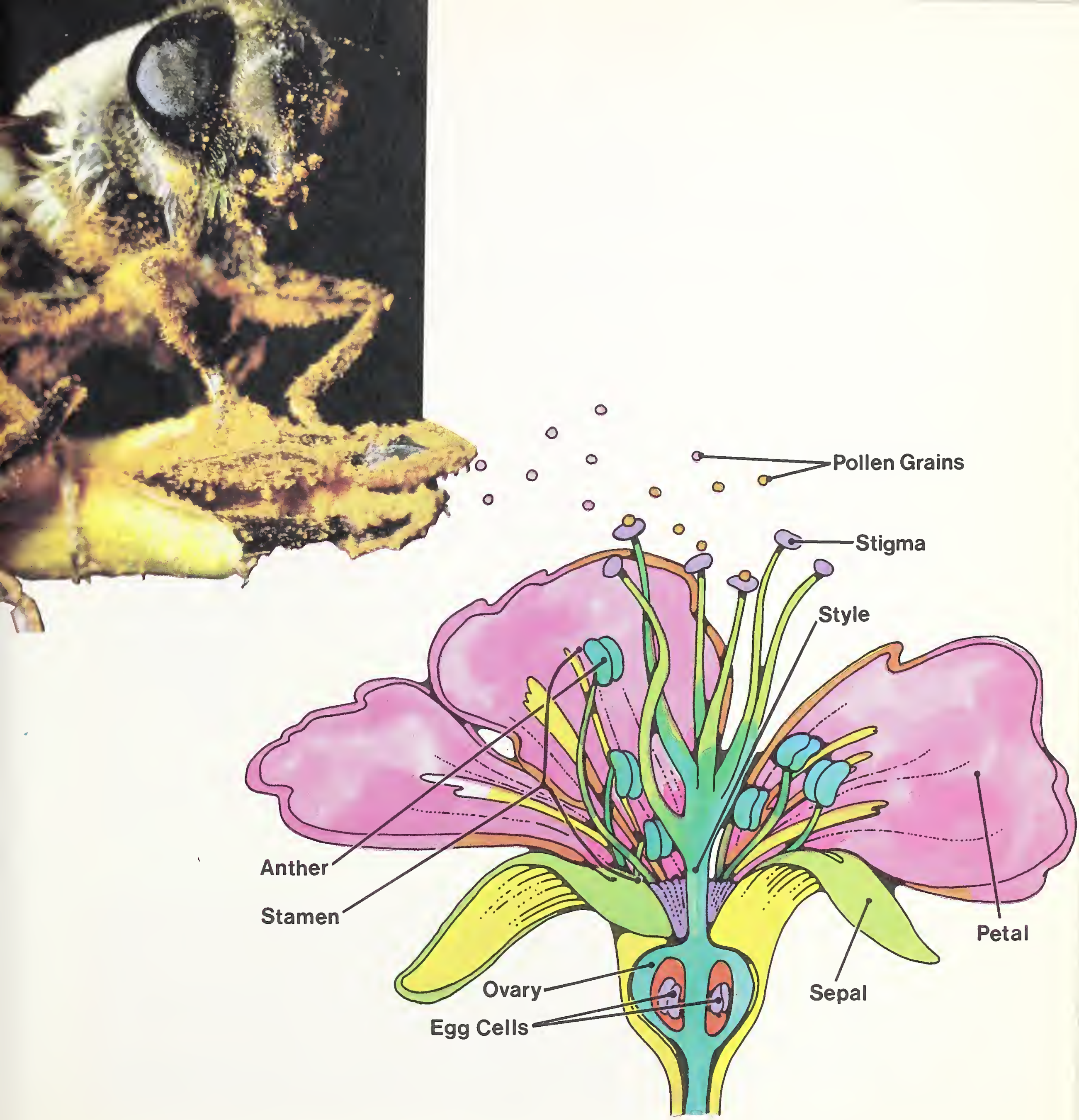
FINDING OUT

What do the parts of some flowers look like?

You will need: sharp scissors, flower from 2 or 3 plants such as tulip, sunflower, cherry, and iris

- Draw a picture of each flower. Try to find the anther, stigma, and ovary. Label these parts. You may wish to use the drawing on page 73 to help you.
- Carefully, cut open each part of the flowers.
- Draw what you see.

How were the same parts of each flower alike? How were they different?


Pollen Grains
Stigma
Style
Anther
Stamen
Petal
Sepal
Ovary
Egg Cells

the ovary, one sperm cell fertilizes one egg cell to form a new cell. This cell becomes an embryo. The other sperm cell joins with another kind of a cell to form food for the embryo. Why do you think the embryo needs this food?

As the embryo and its food grow in the ovary, some other things take place in the flower. One of these things is that a covering called the *seed coat* forms around the embryo and its food. The seed coat, embryo, and food make up a seed. Another thing that takes place is that the ovary grows around the seed. When the ovary becomes large, it is known as the *fruit*. Still another thing that takes place during this time is that certain parts of the flower dry up. These parts are the *stamen, sepals, petals,* and *style*. What might happen if these parts did not dry up?

Starting over again. Sometime during the fall of the year, the fruit of an apple tree falls to the ground. Some of this fruit may be carried far away from the tree by animals. Over the winter, the fruit may dry up or decay. Many of the seeds, however, stay on the ground during the winter. During this time, the embryos stop growing. In the spring, the embryo inside many of the seeds begins to grow again. Until the embryo becomes a young plant with leaves, it uses the food inside the seed.

The young plant grows for several years. Then one spring, the plant grows flowers. At this time, the young apple tree becomes an adult apple tree. The adult apple tree may grow flowers, seeds, and fruit of its own every year for about thirty years. But, eventually, the tree grows old and dies.

What are some other flowering plants that have fruit? Which of these fruits do you like to eat?

Exploring on Your Own

Plants are often said to be either annuals, perennials, or biennials. Find out how being annual, perennial, or biennial affects the life cycle of a plant.

FINDING OUT

What does the inside of an apple look like?

You will need: 2 or 3 different kinds of apples, knife, 2 or 3 glasses of water

- Using the knife, cut the apples in half as shown.
- Look at the inside of each apple. Draw what you see.

How was the inside of each kind of apple alike? How was it different?

- Take the seeds out of the apples.
- Place the seeds from each apple in a different glass of water.
- Let the seeds soak overnight.
- The next day, use the knife to cut open some of the seeds from each kind of apple. Look at the inside of the seeds. Draw what you see.

How were the seeds of each apple alike? How were they different?

A Second Look

1. What makes the life cycle of a fern different from the life cycle of many other kinds of plants?
2. How are the life cycle of a pine and the life cycle of an apple tree alike? How are these life cycles different?

3 Some interesting animal life cycles

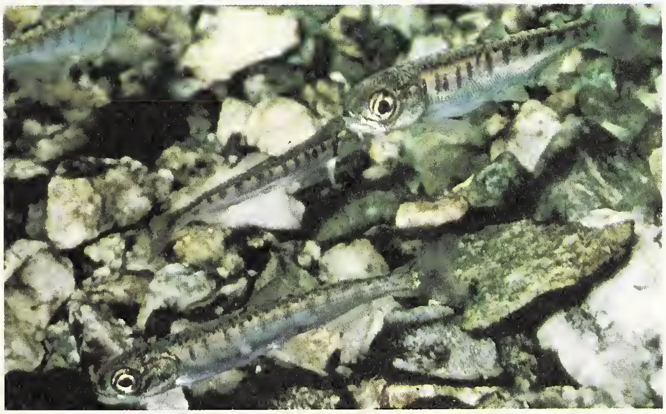
Have you ever been to a zoo? If so, you probably have seen many different kinds of animals. But animals in a zoo are just a few of the thousands of different kinds of animals that live on the earth. What are some animals you have seen in a zoo? What are some other kinds of animals that you know of?

Life cycle of two kinds of fish

As with plants, people who study animals often list them in groups. One such group is made up of many different *fish*. Fish are alike in that they breathe by taking oxygen from water through parts of their body called *gills*. In what ways are fish important to people? Why do you think it is important for people to know about the life cycle of fish?

Life cycle of salmon. Among the many different kinds of fish is the *salmon* [SAM-uhn]. There are several kinds of salmon. However, each kind has a life cycle which is very much the same. The life cycle of new salmon begins in a shallow stream. An adult female salmon makes a hole in the gravel on the bottom of the stream. The female salmon does this by slapping the gravel with her tail. When the hole is formed, the female and an adult male salmon swim into it. The female then releases some egg cells from her body. The male releases some sperm cells from his body. Almost all the egg cells are fertilized by the sperm cells to form salmon eggs. The eggs are then covered by gravel as the female digs a new hole. Adult salmon may repeat this process five or six more times.

About three months after fertilization, the salmon eggs hatch. The tiny, young salmon remain under the gravel until they are big enough to feed on smaller fish. While the young salmon grow under the gravel, they get the food they need from a yolk sac. The yolk sac is attached to their body when they hatch.



Why do you think the colour of these young salmon is important to them?

The trip back to their stream is often very difficult for adult salmon. Why might this be so?

A year after most young salmon swim out of the gravel, they cannot find enough food in their stream. So, they begin to travel. Young salmon may travel hundreds of miles away from their stream. Most of these fish travel to the ocean. There they stay from one to seven years. Then, as adult salmon, they start to travel again. This time, they travel from the ocean to a stream in order to reproduce. Thus, the life cycle of new salmon will begin.

Most adult salmon swim back to the stream where they hatched. Once the salmon leave the ocean, they stop eating. During the trip to the stream and during reproduction, the adult salmon get the food they need from stored fat in their body. After reproduction, most adult salmon are washed downstream, where they die.

Do you know of any other animals that travel great distances during part of their life cycle? If so, what animals are they? Why do they travel?

For You to Think About

The life of a young salmon is very dangerous. Only from 30 to 100 young salmon out of about 3,000 may live to travel from their stream. Why do you think this is so?

Life cycle of grunions. Along with salmon, another kind of fish is the *grunion* [GRUHN-yuhn]. Grunions are small fish that live off the coast of California. These fish have interested people for many years. The main reason for this is that grunions reproduce in the sand along the coast. And they seem to know exactly when to come ashore to do this!

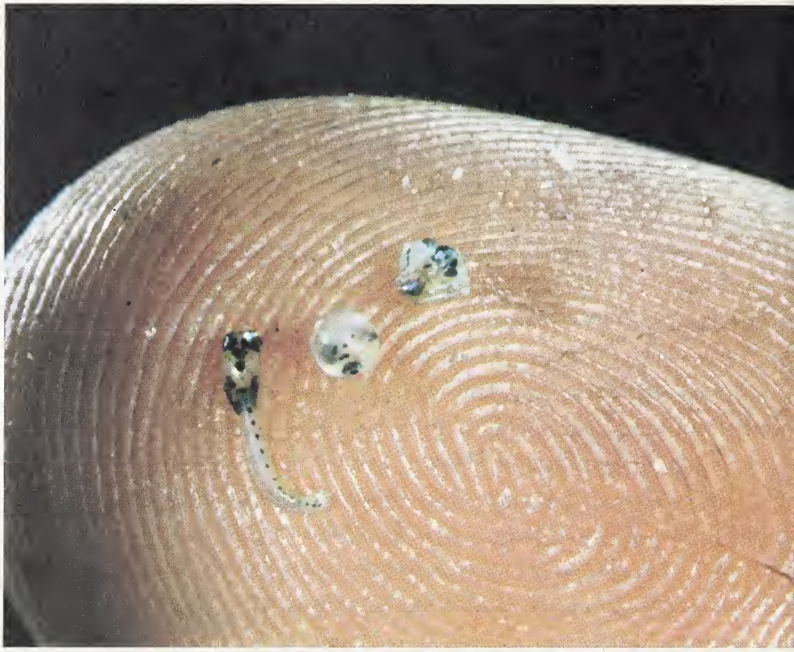
Each year between February and September, adult grunions come up on the sand by riding waves. The fish do this at a certain time during each of these months. That time is just after the moon is full. At this time, the high tide begins to go down. High tide takes place when the water comes up on the beach farther than it does at other times of the month.

Once on the sand, the female grunions lay egg cells in the sand. Male grunions fertilize the egg cells to form grunion eggs. The adults are then carried back into the ocean by waves. Why do you think the adult grunions go back into the ocean?

Exploring on Your Own

See if you can find out why grunions reproduce only during certain months after the tide is high. Looking in reference books under the headings *grunion* and *biological clocks* may help you.

This picture shows a grunion egg, a grunion egg hatching, and a newly hatched grunion on the finger of a person. Point out each stage.



Grunion embryos grow inside the eggs in the sand for about two weeks. At the end of this time, the waves of the next high tide wash the eggs out of the sand. The eggs break open and the young grunions pop out! The young grunions are then carried out to the ocean by waves.

After a year in the ocean, the young grunions become adults. They may come up on the sand to reproduce up to eight times a year during the next year or two, before they die. The life cycle of a grunion is very short compared to the life cycle of some other living things. Do you know of any other animals that have a short life cycle? If so, what are these animals, and how long do they live?

FINDING OUT

How can raising fish help you learn about their life cycle?

You will need: bucket, about 15 L glass container, clean aquarium gravel and 2 or 3 aquarium plants (from a pet store), 2 male guppies, 2 female guppies, fish food, small piece of cardboard

- Fill the bucket with water. Let the water stand for 2 or 3 days.
- Line the bottom of the container with about 3 cm of gravel.
- Cover the roots of the plants with gravel.
- Put the cardboard on the gravel as shown.
- Fill the container by slowly pouring water on the cardboard. When finished, remove the cardboard.
- When the water is clear, put the guppies in the container.
- Feed the guppies a small amount of food every day.
- When you see newborn guppies in the container, put the adult guppies in another container.

How big were the new guppies soon after they were born?

- Keep a record of how big the young guppies grow.
- When the young guppies become adults and have new guppies, take the adults out of the container.

About how many days did the young guppies take to become adults and have new guppies? About how much did the guppies grow from the time they were born to the time they became adults? What other things did you learn about the life cycle of a guppy?

Life cycle of an amphibian and a reptile

Besides the fish, two other groups of animals are the *amphibians* [am-FIHB-ee-uhnz] and the *reptiles* [REHP-tuhlz]. Most adult amphibians have lungs and live on land near water. But during the early stages of their life cycle, most amphibians have gills and live in the water. Reptiles, however, have lungs and live in the water or on land during their entire life cycle. An amphibian that you may know of is the frog. A common reptile is the snake. What other amphibians and reptiles do you know of?

For You to Think About

Frogs eat many insects. Because of this, many people feel that frogs are very important to them. Why might it be important that frogs eat many insects?

Life cycle of frogs. If you have ever seen a frog, you know that frogs have smooth, moist skin. They also have strong hind legs which help them hop. Most kinds of frogs also have the same kind of life cycle. The life cycle of new frogs begins in the spring. At this time, an adult female frog lays egg cells in calm water such as that of a pond or a stream. As the female lays the egg cells, an adult male frog fertilizes them with sperm cells. The fertilized egg cells form frog eggs.

About two weeks after fertilization, the frog eggs hatch. But the new frogs, called *tadpoles,* do not look like adult frogs. In fact, young tadpoles look more like fish than like adult frogs! Tadpoles have gills and tails. What other baby animals do you know of that do not look like adult animals of the same kind?

As tadpoles get older, hind legs begin to grow out of their body. Soon, front legs begin to grow out, and lungs develop inside the tadpoles. During this time, the tail of each tadpole starts to shrink.

Tadpoles enter youth once their tail has disappeared. During youth, which usually begins in the summer, most young frogs are able to climb out of the water.

But they do not go far from the pond. Frogs must keep their skin moist. They are also safer in water than they are on land. Why do you think this is so?

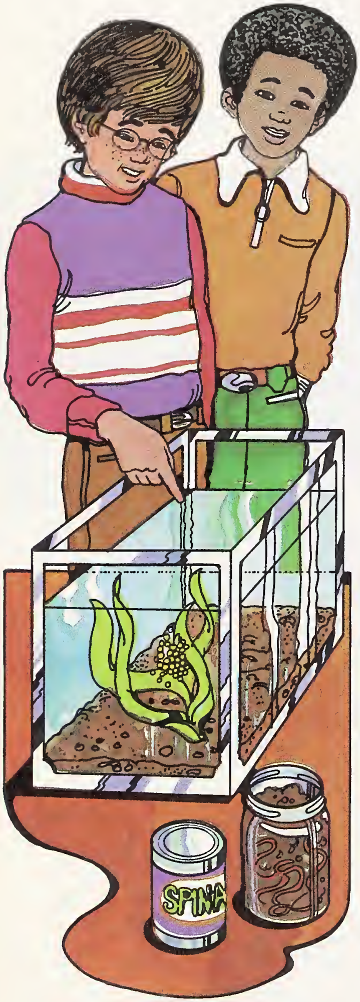
When winter comes, young frogs swim to the bottom of the pond along with adult frogs. There, each frog buries itself in the mud to wait for spring. While the frogs are under the mud, they *hibernate*. That is, they do not move. Their heart slows down until they almost seem dead. When frogs hibernate, they use stored fat from their body for food. They take oxygen from the water through their skin. Why do you think frogs spend the winter in this way?

Young frogs enter the adult stage of their life cycle when they are about two years old. Many frogs live for about fifteen years. Why might a frog not live long enough to complete its life cycle?

FINDING OUT

How can you hatch frog eggs?

You will need: bucket, large aquarium tank, glass top for the tank, aquarium gravel, aquarium plants, frog eggs (from a pond or a pet store), cooked spinach, tubifex (small worms from a pet store), earthworms



- Fill the bucket with water. Let the water stand in the bucket at least 2 days.
- Line the bottom of the tank with about 3 cm of gravel.
- Slowly fill the tank about three-fourths full with the water. Place the plants and the frog eggs in the tank.
- Watch the eggs every day. When the eggs hatch, put some spinach and tubifex in the water for the tadpoles to eat.
- When the tadpoles become young frogs, take some of the water out of the tank. Put gravel at one end of the tank so that the gravel is above the water level.
- Frogs need room to move. So, you may want to keep one or two young frogs and let the others go free. Or, put them in other tanks.
- Frogs usually eat only things that move. So to feed your frogs, you might put a worm on the end of a straw and wiggle it in front of them.
- Put the glass cover over the top of the tank. Do not handle the frogs any more than necessary.

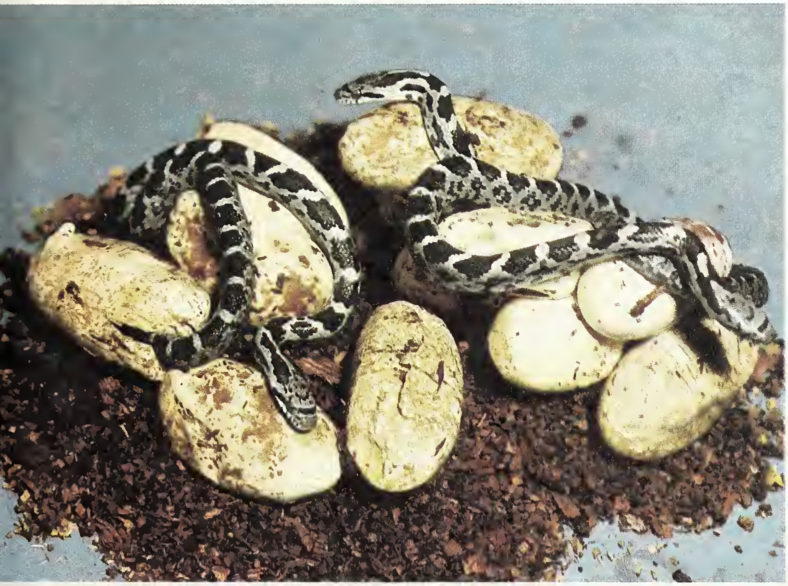
What things did you learn about the life cycle of a frog?

Life cycle of snakes. Like new frogs, new snakes usually begin their life cycle in the spring. However, the life cycle of snakes and other reptiles is quite different from the life cycle of frogs and other amphibians. To begin the life cycle of new snakes, an adult male snake deposits sperm cells inside the body of an adult female snake. When the sperm cells fertilize the egg cells of the female, snake eggs are formed inside the body of the female.

About a month after fertilization, a female snake lays her eggs in a hole in the ground or in between rocks. These eggs are covered with a leathery shell. The shell helps protect the growing snake embryos from other animals and the weather. Why do you think growing snake embryos need to be protected from these things?

Exploring on Your Own

Many people are afraid of snakes. These people do not realize that most snakes are not harmful to people. In fact, snakes are often helpful to people. See if you can find out how they are helpful.



Though the embryos of many kinds of snakes grow inside eggs, the embryos of some kinds of snakes grow inside the body of their mother. Snakes which grow inside their mother are born live.

In about two months, the growing snakes become too big for their shell. This causes the shell to crack. The snakes break their shell further with a small egg tooth which sticks out from their jaw. Once the young snakes are out of their shell, they shed the egg tooth.

After young snakes shed their egg tooth, they look very much like adult snakes. The young snakes also do many things that adult snakes do. For example, young snakes find their own food and protect themselves from enemies. During very hot days, snakes sleep in dens under rocks or under the ground. During the winter, snakes hibernate.

Though young snakes are able to do many of the same things adult snakes do, very few young snakes live to be adults. Those young snakes that do live become adults when they are about two to three years old. Adult snakes may live to be about twenty years old. Why do you think few young snakes live to become adults?

Life cycle of two mammals

There is another group of animals which is very different from fish, amphibians, and reptiles. This group is made up of animals called *mammals.* One thing that makes mammals different from other animals is that female mammals form milk inside their body. This milk is food for their young. Another thing that makes most mammals different is that they have hair on their body. What are some mammals you know of?

Life cycle of whales. Most mammals live on land. However, there are a few mammals that live in water. Whales, for example, are mammals that live in water. But unlike fish, whales have lungs. Therefore, whales must come to the surface every few minutes to breathe. They breathe through a hole in the top of their head called a *blowhole.*

Whales are the largest animals on the earth. Some whales are about one third as long as a football field. The tongue alone of some whales weighs as much as two cars!

Whales usually swim in cool ocean waters. But in the summer, many whales swim to warm ocean waters. At this time of year, an adult male whale deposits sperm cells inside the body of an adult female whale. After fertilization, an embryo grows inside the female. The adults then swim to cool ocean waters where they stay until just before the young whale is born.

From ten to seventeen months after fertilization, the whales return to warm waters. Here, the female gives birth to a new whale. Newborn whales may be 7 m long and weigh 2700 kg! The newborn whale drinks milk from its mother's body for about seven

months. When the young whale grows big enough to live in cool water, the whales travel again. Though the young whales can get their own food by this time, they are protected by the adults as they travel.

Many whales live to be about twenty years old. But years ago, few whales lived that long. Thousands of whales were killed by hunters. People used parts of the dead whales for fuel and meat. Whales are still hunted by some people. But many people are trying to stop or control the hunting of whales. Why do you think this is so?

Exploring on Your Own

As was mentioned, people have used the bodies of dead whales for fuel and meat. See if you can find out what else people have used the bodies of whales for.

Life cycle of baboons. Like whales, many other mammals protect their young as they grow. Mammals called *baboons* do this. Baboons are large monkeys which live in Africa and Arabia. Baboons travel in groups of ten or more. How do you think traveling in groups is helpful to baboons?

There are several kinds of baboons. Each kind has much the same life cycle. This life cycle is also similar to the life cycle of many other mammals that live on land. The life cycle of a new baboon begins after an adult male baboon deposits sperm cells inside the body of an adult female baboon. Usually, one sperm cell fertilizes one egg cell. After fertilization, an embryo grows inside the female baboon for several months.

After birth, a young baboon drinks milk from its mother's body. During the first six months of a young baboon's life, it mostly sleeps, eats, and clings to its mother. After this time, the young baboon may be cared for by other baboons, as well as its mother. The other baboons help watch over the young baboon and keep it clean.

The young baboon learns things by playing, by exploring, and by watching other baboons. Some of the things the young baboon learns are how to find food, what to eat, and what things are dangerous. When the young baboon is about a year old, it must find its own food. The young baboon must also begin to protect itself.

Both male and female baboons become adults when they are about four to five years old. A female may have a baby baboon every other year thereafter. However, a male baboon may not father a baby baboon for four to five more years.

Usually, only a few male baboons father baby baboons. These baboons are called *dominant* males. The dominant males do many things for the group. For instance, they protect the group from danger when the group is away from trees where baboons are safe. Dominant males see that the members of the group behave. Dominant males also choose where the group will feed and where it will sleep. How are the things these males do important to the life cycle of baboons?

Baboons live to be about fifteen years old. What other mammals do you know of that have a life cycle similar to that of the baboons?

A Second Look

1. Where do salmon go to start the life cycle of new salmon?
2. What makes the life cycle of a grunion interesting to people?
3. What happens to a frog or a snake as it hibernates?
4. In what ways do mammals need to be cared for during the early stages of their life cycle?

Workers Who Use Science

Among the many different kinds of fish, there are some fish that are more important to people than others. These are the fish that people catch mainly for food and for sport. Because of overfishing and pollution, many of these fish are in danger of becoming extinct. Many people who realize this have built fish hatcheries, or places where fish are raised. Some people who work at fish hatcheries are called *fish-culture technicians.*

In order to do their job, fish-culture technicians need to know about the life cycle of the fish they raise. For example, these people need to know when the fish reproduce. After the fish reproduce in hatcheries, fish-culture technicians take care of the fish eggs. Later, when the eggs hatch, the technicians take care of the young fish until they are old enough to be released into lakes and streams. Or the fish are taken care of until they are old enough to be sold to companies that sell fish for food.

To find out more about fish-culture technicians, try to find answers to these questions:

What kinds of fish are most often raised in hatcheries?
Besides fish hatcheries, where else do some fish-culture technicians work? What do these people do?
What are fish ladders, and how might they be important to the life cycle of fish?

Along with sources of your own, writing to the following source may help you: Department of Industry and Agriculture, Fisheries and Food Products, Tower B, 112 Kent Street, Ottawa, Ontario K1A 0H5.

Reviewing the Main Ideas

Living things pass through different stages as they grow. Some of these stages are youth, adult, and old age.

A life cycle is the time from the beginning of a plant or animal's first stage of growth to the end of its last stage of growth.

Most plants and animals start to grow from a single cell.

A cell which is the beginning of the life cycle of a living thing is the result of reproduction.

Some groups of plants that have different life cycles are the spore-bearing plants, the cone-bearing plants, and the flowering plants.

Some groups of animals that have different life cycles are the fish, the amphibians, the reptiles, and the mammals.

Reading About Science

Blassingame, Wyatt. *Wonders of Frogs and Toads.* Toronto, Ontario: Dodd, Mead & Company (Canada) Ltd., 1975.

Gambino, Robert. *Easy to Grow Vegetables.* Don Mills, Ontario: Fitzhenry and Whiteside Ltd., 1975.

Horwood, Harold. *The Foxes of Beachy Cove.* Toronto, Ontario: Doubleday Canada Limited. 1975.

Stepp, Ann. *Grunion: Fish Out of Water.* Don Mills, Ontario: Fitzhenry and Whiteside Ltd., 1971.

Watson, Jane W. *Whales: Friendly Dolphins and Mighty Giants of the Sea.* Stratford, Ontario: Scholar's Choice Ltd., 1975.

Testing for Understanding

Ideas to Check

On your paper write *T* for each sentence below that is true. Write *F* for each sentence that is false.

1. Young amphibians and reptiles get the food they need from milk that is made in their mother's body.
2. The life cycle of new salmon begins on the bottom of a stream.
3. How a new plant or animal will grow is decided when a sperm cell and an egg cell join together.
4. The life cycle of a new pine begins in a flower.
5. Young tadpoles look more like fish than adult frogs.
6. An apple tree is a spore-bearing plant.
7. Some animals can get food by themselves as soon as they hatch.

Words to Use

Write on your paper the word or words that best fit in each blank below. Choose from these words: *spore, sperm cell, egg cell, hibernate, fertilization, fruit, cone, reproduction, seed, embryo, life cycles, amphibian, mammal, fish.*

1. Some animals ____ during part of their life cycle.
2. A fern begins its life cycle as a single cell called a ____.
3. ____ is the means by which every living thing produces new living things that are like itself.
4. When the ovary of a seed plant grows large around new seeds, it is called the ____.
5. An ____ is a female sex cell.
6. After fertilization, a new plant or animal cell divides to form an ____.
7. A common ____ is the frog.
8. A grunion is a ____.

Having Fun with Science

What Am I?

1. I am a cone, but I would not taste good with ice cream.
2. I have gills, but I am not a fish.
3. I am a cycle, but I do not have wheels.

Word-clue Game

On a piece of paper write the missing letters of the word about life cycles that best fits each definition below.

_ _ L _	helps fish breathe
_ _ _ _ I _ _	snake
F _ _ _ _	enlarged ovary of seed plants
_ _ _ _ E	cell which begins new ferns
C _ _ _	part of pine trees
Y _ _ _ _	stage of life cycle after birth
_ _ _ _ _ _ _ C _	to produce new living things
_ _ _ L	tiny unit of living matter
_ _ _ _ E	mammal that lives in water

Things to Do

1. Animals are often said to be either *cold blooded* or *warm blooded*. Find out what these terms mean, and find out the names of some cold-blooded animals and some warm-blooded animals. Also try to find out how being cold blooded or warm blooded affects the life cycle of an animal. Report your findings to your class.

2. Ask your teacher if you may invite a worker from a zoo or from an animal hospital to your school. Make a list of questions about animals and their life cycle that you would like answered.

3 Matter and You

1 **Properties of matter**
2 **What is matter made of?**
3 **Elements**
4 **Recipes for matter**

Did you know that things we see and touch are called matter?
And, did you know that all matter is made of millions and billions of tiny little parts?
And, did you know that the parts of matter are so small that they can't be seen?
Did YOU know that some matter should be seen and not heard?

What is some matter you can see?

What is some matter that can make noise?

Do you think that all matter is alike in some ways?

If so, how might it be alike?

1 Properties of matter

How would you describe yourself? Are you tall? How old are you? You would most likely describe yourself as most other people would describe themselves. You might say that you eat. You breathe. You have a mouth and a brain. You have a head, a heart, and so on.

Whenever you are describing yourself, you are naming your *properties* [PROP-urt-eez]. Your properties are those things which are a part of you. What are some of your other properties?

The properties which all people have are called *common properties.* It is these properties which make all people alike. Would you say a mouth is a common property of all people? Why or why not?

Some properties are not part of all people. These are called *special properties.* While most people have hair, not all people have red hair. Red hair is a special property of some people. Skin is a common property of all people. But would you say freckles on the skin are a special property of people? Why or why not?

Look at all the members of your class. What are some other common properties of these people? What are some special properties of these people?

Some common properties of matter

There are many common and special properties of people. But besides people, there are many other things around you. You and all things around you are sometimes called *matter.* All matter has some common properties. You may be surprised, but even you and this book have some common properties!

Two for one. Have you ever boarded a bus when all the seats were taken? If so, you know you could not sit down until someone stood up. No two people or things can be in the same space at the same time. Matter cannot penetrate, or go into, other matter. This common property of matter is called *impenetrability* [ihm-PEHN-uh-truh-BIHL-uht-ee].

The air around you is also matter. When you walk into a room, the room is filled with air. How do you think you can move into a space which is already filled with this matter?

Moving or not moving. Another common property of matter is called *inertia* [ihn-UR-shuh]. Inertia has to do with the movement of matter.

When matter is moving, it is said to be in motion. Because of inertia, matter will stay in motion until someone or something makes it stop. When a ball is rolling on a floor, the ball will keep rolling because of its inertia. A ball will not stop by itself. What are some things which might cause a rolling ball to stop?

When matter is not moving, it is said to be at rest. Because of inertia, matter will stay at rest until someone or something makes it move. When you put your pencil on your desk, the inertia of the pencil keeps it from moving. Your pencil will not move by itself. What things might cause your pencil to move?

FINDING OUT

How can you show that an object has inertia?

You will need: small cart or toy car, paper, small objects such as a piece of wood and a rubber ball

- Place the small object on top of the cart.
- Quickly pull the cart toward you.

What happened to the object? Why?

- Place the rubber ball on top of the piece of paper.
- Quickly jerk the paper away.

You should be able to jerk the paper away without making the ball roll. Why?

- Place the object on the cart again.
- Begin moving the cart slowly but then gain some speed.
- Quickly stop the cart.

What happened to the object? Why?

Still moving. You most likely move many things each day. What things have you moved today?

Because all matter has inertia, you must use force, or strength, whenever you move something. Some things at rest need more force than others to move them. The force needed to push a desk is greater than the force needed to push a book. This is because a desk has more *mass* than a book. Mass is the amount of matter in an object.

As you remember, things that are in motion also have inertia. Therefore, a force is needed to stop these things. The force needed to stop something that is in motion depends on its mass and speed. Suppose someone dropped a nail and a hammer in a bucket you were holding. Which would need more force to stop its motion, the nail or the hammer? Why? Would a hammer that is thrown take more force to stop than one that is dropped? Why? What are some things you have stopped moving? Which of these things needed more force to stop them than others? Why?

For You to Think About

People use their muscles to move things every day. But there are many other forces which can put things in motion. What might some of those forces be?

Exploring on Your Own

If you went to the moon, your weight would be one-sixth your weight on earth, because the force of gravity is much less on the moon. Compare the force of gravity of the earth with other planets such as Mars and Neptune. Find out what you would weigh on some of these planets. Books about planets may help you.

Heavy or light? Still another common property of matter is *mass*. What was your mass when you were born? What is your mass now? Some matter, such as trucks and buses, has a much greater mass than other matter. What are some things that have very little mass?

Like mass, weight depends on the amount of matter in an object. But weight is different from mass. The weight of matter is caused by the pull of the earth. The earth pulls on all matter with a force called *gravity*. Your weight is a measure of the pull of gravity on you. If you were to let go of your pencil, gravity would pull it to the earth. What do you think would happen to your pencil if there were no gravity?

The force of gravity becomes weaker as you move farther from the earth. People have travelled in certain parts of space where there is little or no gravity. They had little or no weight, but their mass—quantity of matter—remained unchanged. The property of weight is different from the property of mass. Mass does not change like weight does when the amount of gravity changes.

Filling up a space. All matter takes up space. The amount of space something takes up is its *volume* [VOL-yuhm]. The volume of something depends on how long, how wide, and how thick it is. Things that are big, like mountains, have a large volume. Things that are little, like ants, have a small volume. What things do you think have about the same volume as you?

FINDING OUT

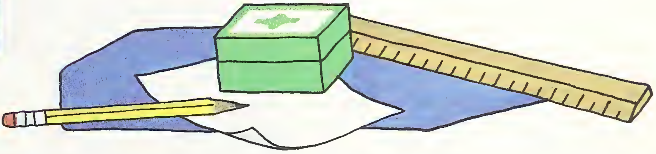
How can you find the volume of some of the things around you?

You will need: pencil, paper, ruler

The volume of an object is found by multiplying its length times its width times it height. The box in the picture is 8 cm long, 5 cm wide, and 5 cm high. The volume of the box, then, is $200\ cm^3$.

- Find the volume of your science book.
- Find the volume of your classroom.
- Guess the volume of some of the other things around you; then measure their volume.

How close were your guesses?



For You to Think About

Suppose you put a number of things into a tub of water. What would happen to those things which have a density greater than water has? What would happen to those things which have a density less than water has? What would happen to those things which have a density the same as water has?

How much is there? Because all matter has mass and volume, all matter has *density* [DEHN(T)-suht-ee]. Density is the amount of mass in a certain volume.

Suppose you have two bags that are the same size. One bag is filled with coins. The other is filled with paper. Their volume would be the same. If you push each bag, how would you know which bag holds the paper?

The mass of the bag of coins would be greater than the mass of the bag of paper. And since their volume is the same, the bag of coins would have the greater density.

Each of the containers has the same volume. What is in each container? Which has the greater mass? Why? Which has the greater density? Why?

Some special properties of matter

As you may remember, special properties are properties that are not part of all matter. Special properties belong to just some kinds of matter.

Breaking apart. Have you ever broken a glass or cracked a mirror? If so, you have seen what can happen to something that has the special property of *brittleness.* This property causes matter to break apart when it is hit or dropped.

What are some other things that have brittleness? Do you think you have this special property? Why or why not?

For You to Think About

There are some important uses for things that do not have colour. Some food is sold in glass jars. You can see what is in the jar without having to open it. What are some other uses of things that have no colour?

Red, white, and blue. As you look around, you may see many different colours. What things do you see that are blue? Red? What other colours do you see?

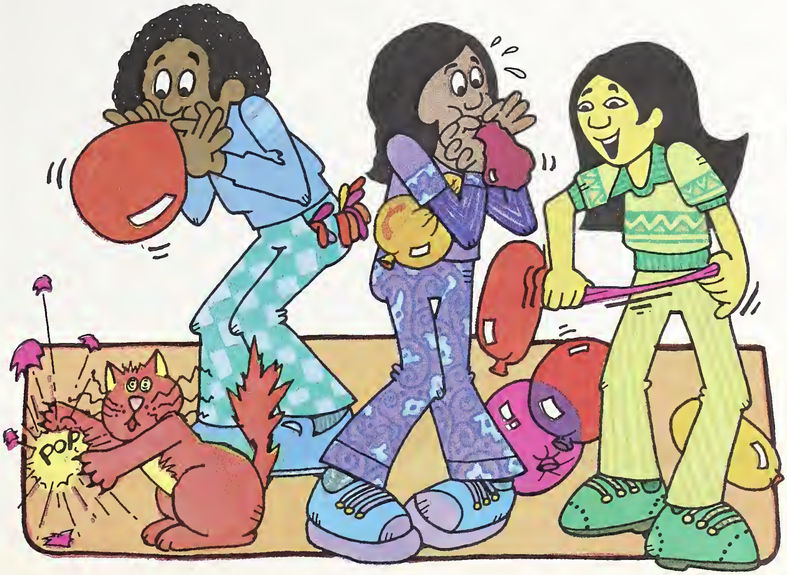
Although many things have colour, there are some things that have no colour. *Colour* is a special property of matter. When you look out a window, you may see grass or a car. The reason you can see through a window is because the glass in most windows has little or no colour. What are some other things that have no colour?

Squeeze and stretch. Have you ever held a rubber ball in your hand? If so, what happens to its shape when you squeeze it? What happens to its shape when you stop squeezing it?

Still another special property of matter is *elasticity* [ih-LAS-TIHS-uht-ee]. Elasticity is what makes some matter keep its shape. When you stretch a rubber band, you change its shape. When you let go, its elasticity will make it go back to its own shape.

Many kinds of matter have elasticity. But they do not have to be soft like rubber. In fact, some strong metals have elasticity. You may have seen doors with metal springs on them. When you open the door, the spring stretches out. When you let go of the door, the spring pulls back.

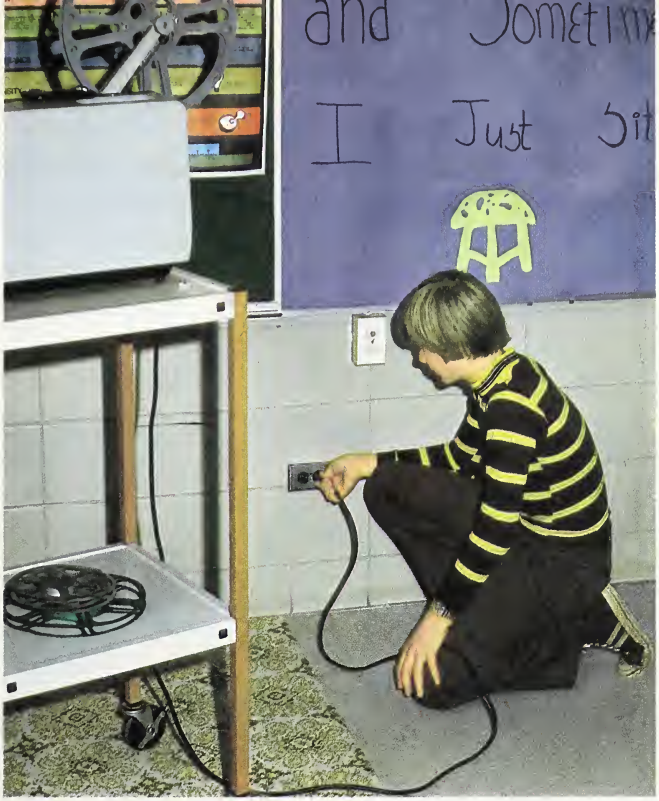
What are some other things which have elasticity?



Just passing through. Some kinds of matter have the special property of allowing heat to pass through them. These kinds of matter are often called conductors of heat. They have a special property called *conductivity* [KON-DUHK-TIHV-uht-ee].

Heat can pass through some matter more easily than it can pass through others. A good conductor lets heat pass through it easily. Pots used for cooking are often made of good conductors of heat. Heat from a stove can pass through the pot to heat the food. The handles on most pots are poor conductors. Heat cannot pass easily through them. Why do you think poor conductors of heat are used for the handles? What might be some other uses of good conductors of heat?

Besides heat, electricity can pass through some matter more easily than through other matter. Some kinds of matter will not allow electricity to pass through them at all.



When you flip a switch on a wall, electricity passes through wires to light a lamp. These wires are good conductors of electricity. The switch, however, is made of a nonconductor. This keeps electricity from passing into you! What are some other things which are good conductors of electricity?

A Second Look

1. What are some common properties of matter?
2. What are some special properties of matter?

2 What is matter made of?

If you and a friend want to share one glass of water, you might use two glasses. You might pour half of the water into each glass. But suppose you have five friends. You would need six glasses. You might pour an equal amount into each glass. But, how many times could you divide the water?

Dividing matter

Although you might have many friends, there is a certain point at which you could no longer divide the one glass of water. In fact, all matter can be divided only to a certain point.

The smallest part into which you can divide water is a water *molecule* [MOL-ih-kyoo(uh)l]. A molecule is the smallest part of matter which still has the properties of that matter. If a water molecule were divided into anything smaller, it would no longer be water.

Molecules are very, very small. One drop of water may seem to be small. It may even be hard to see. A drop of water, however, has billions and billions of water molecules in it!

Because molecules are so small, people who study molecules use special *microscopes* [MY-kruh-skohps]. The ones used to see molecules are very powerful. They make things look many thousand times larger than they are. But even with these microscopes it is still hard to study a molecule. Why do you think people study molecules?

This woman is looking through an electron microscope. An electron microscope can be used to study molecules. What do you think can be learned about molecules in this way?

Smaller than molecules

You may remember that a water molecule cannot be divided into smaller parts of water. But, a molecule of matter can be broken down into smaller parts called *atoms* [AT-uhmz]. Atoms are sometimes called the "building blocks" of matter. Why do you think this is so?

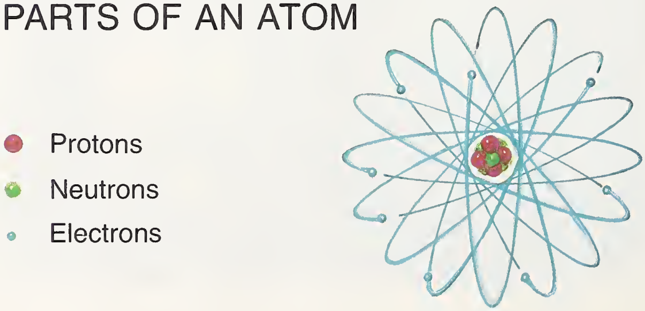
As with molecules, special microscopes are used to study atoms. Why do you think it is harder to study atoms than it is to study molecules?

It took people a long time to find out that matter is made of molecules and atoms. The next question in people's minds was "What are atoms made of?" Since atoms are hard to see, the answer was not easy to discover.

By studying different kinds of matter, people have learned that matter acts in certain ways. By watching some of the ways matter acts, people have been able to figure out what atoms are made of.

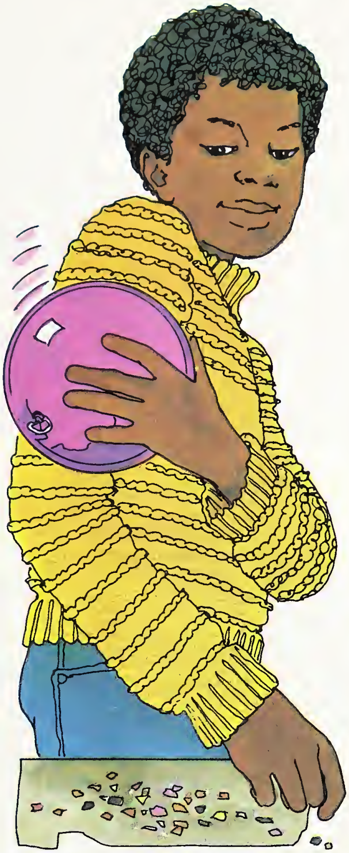
There are many kinds of atoms. But atoms in general are made up of three kinds of particles. They are known as *electrons, protons,* and *neutrons.* Each kind of atom has a different number of electrons, protons, and neutrons. The picture on this page shows what one kind of atom is thought to "look" like.

PARTS OF AN ATOM



For You to Think About

Why do you think it is important that people study the parts of an atom?



FINDING OUT

How can you "watch" how electrons make things act?

You will need: balloon, paper

When some kinds of matter are rubbed together, electrons are "rubbed off." The rubbing off of electrons makes these kinds of matter act in certain ways.

- Blow up the balloon and tie a knot at the end.
- Tear the paper into tiny pieces.
- Rub the balloon on a shirt or other piece of cloth.
- Bring the balloon close to the pieces of paper.

What happens to the pieces of paper?

- Rub the balloon on the cloth again.
- Place the balloon on the side of your desk or on a wall.

How does the balloon act?

- Rub a few other things together.

How do some of these things act when electrons are rubbed off?

A Second Look

1. What is a molecule? What are atoms?
2. How are microscopes useful in studying molecules and atoms?

3 Elements

You have most likely seen advertisements for new products. Radio, TV, and magazines have these ads showing new things to buy. Each year there are new models of cars. There are new shampoos. There are new kinds of clothing. What are some other things which are new this year?

With all the new things—plus the old things—there are billions of different kinds of matter! Although each kind of matter is made of atoms, there are not billions of different kinds of atoms. In fact, much of the matter around you is made up of just a few kinds of atoms.

Only one kind of atom

Matter that is made of only one kind of atom is called an *element* [EHL-uh-muhnt]. Iron and gold are elements. There are just over a hundred elements

The people in this picture are panning for gold. Gold can sometimes be found in rivers and around riverbeds. How do you think the pans are used to help people find gold?

known. Most of these elements can be found in the earth. About fifteen elements have been "made" by people in special laboratories. What are some things around you which you think are elements?

Discovery of elements. The idea that elements make up matter is an old idea. Even before people knew about atoms, people believed that all matter was made up of small parts.

Long ago, some people believed that there were only four elements. They believed that fire, water, earth, and air made up all matter.

Many years later, however, people learned that fire, water, earth, and air were not elements at all. People also learned that there were more than four elements. Even now that over 100 elements are known, the search for new elements goes on. Where do you think new elements might be found?

Exploring on Your Own

See if you can find out what else some elements have been named after. A dictionary or a reference book may help you.

Names of elements. Some of the first elements discovered were named after Greek and Roman gods. The elements mercury, plutonium, and neptunium were named after the gods Mercury, Pluto, and Neptune.

Other elements were named because of how they looked. The Greek word *chloros* means green. So a green element was named chlorine.

The names of countries, cities, districts and scientists have also been used to name some elements. For what places might these elements be named: americium, ruthenium, polonium, and nobelium?

Symbols of elements. One of the first groups of people to study elements was *alchemists* [AL-kuh-muhsts]. Alchemists worked with different elements to see how each element could change.

Alchemists, however, worked mostly on one idea. They believed that elements could be changed into gold. They secretly worked with powders, metals, and liquids. Why do you think they wanted to make gold?

Because their experiments were secret, the alchemists kept all their writing in code. The alchemists had their own symbols for each element they studied. However, alchemists began to share what they had learned with other alchemists. In order for all alchemists to understand the work of each other, they had to learn each other's symbols. Because the symbols were different, they became a problem. Why?

The symbols used for elements today are letters from each element. The symbols **O** and **C** are the first letters of the elements oxygen and carbon. Some elements are known by their first two letters. **Si** and **Ni** are the symbols of silicon and nickel. Why do you think two letters are used for some elements?

Why do you think heat from fire might help this alchemist study elements?

Still other elements are known by their Latin names. Thus, the symbol for iron is **Fe**, which stands for the Latin word *ferrum*. These symbols are used by people around the world. Why might this be so?

Some Common Elements

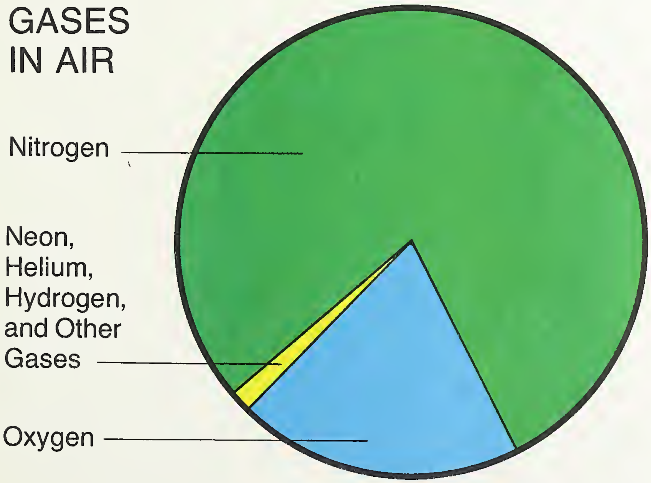
Element	*Symbol*	*Special properties*
Aluminum	Al	light, rustproof, gray metal
Arsenic	As	gray, brittle, poisonous solid
Calcium	Ca	silver-white, light metal found in teeth and bones
Carbon	C	nonmetal found as coal and diamonds
Chlorine	Cl	heavy, greenish gas used in bleaches and disinfectants
Copper	Cu	reddish metal, good conductor of heat and electricity
Gold	Au	soft, yellow metal used for coins and jewelry
Hydrogen	H	colourless, odourless, flammable gas
Iodine	I	heavy, gray crystals used in medicines
Iron	Fe	heavy, silver-white, rusting metal
Mercury	Hg	heavy, silver-white, poisonous liquid metal
Nitrogen	N	colourless, odourless, tasteless gas
Oxygen	O	colourless, odourless, tasteless gas, needed for breathing and for burning
Platinum	Pt	heavy, precious, grayish-white metal
Silicon	Si	nonmetal, the second most abundant element in the earth
Silver	Ag	white metal, can be highly polished, used for coins and silverware (knives, forks, etc.)

Where elements are found

As you may remember, about fifteen elements have been "made" by people. An example is the radioactive element lawrencium. These elements can be made only in special laboratories. However, most elements can be found in and around the earth.

Elements in the air. The elements found in the air are gases. The most common element in the air is nitrogen. The next most common element in the air is oxygen. Oxygen is needed by all living things. How do you get oxygen?

The chart on this page shows which elements are found in the air. While you may not need all these gases to live, they do have important uses. One gas, neon, is used in special light bulbs to make strong, bright lights. What are some other uses for elements that are gases?



Exploring on Your Own

Gold and silver rushes in Canada sent people to some out-of-the-way places for these elements. Find out where most of the gold and silver mines are located in Canada.

Elements in the ground. Not only is oxygen found in the air, but it also makes up most of the earth. Another common element in the earth is silicon. Sand is mostly silicon. Silicon is used to make many of the things around you, such as glass.

You have most likely used many of the other elements from the ground. Copper is taken out of the ground to make coins used for money. In fact, many years ago, pennies were often called "coppers." What are some other elements used for making money?

Another element found in the ground is aluminum. Because of its light weight, this metal has many uses. You may have drunk soda from an aluminum can. Or, you may have opened a door that was made of aluminum. What are some things you have seen which are made of this element?

This mining area has been dug out of the earth to get iron ore. What things do you think are made from iron?

Elements in water. Although many elements can be found in the ground, the oceans of the earth are also good sources of elements. Iodine is one element which has been found in ocean water. However, getting the elements out of the water has not been easy to do. Why do you think this is so?

For You to Think About

Do you think that people will someday get needed elements from the moon and planets in our solar system? Why or why not?

A Second Look

1. What is an element? About how many elements are known on the earth?
2. Why are symbols used for writing the elements?
3. Where are elements found?

4 Recipes for matter

Have you ever watched someone making a pie? If so, that person most likely followed a recipe in making the pie. Maybe you have made something to eat by following a recipe. A recipe tells you how much of each ingredient to use. A recipe also tells what to do with the ingredients. What might happen if you do not follow a recipe?

Matter is made in nature from many "recipes." The ingredients of matter are the elements. Elements from the earth can be mixed to make many kinds of matter.

Just a few ingredients

As you may remember, there are billions of different kinds of matter. But there are only about 100 elements. There are several reasons why so many different kinds of matter can be made from so few elements.

One reason is that a number of elements can join together to make up matter. Some matter is made of just two or three elements. Another kind of matter, however, may be made of fifteen or twenty elements. You are made of at least this many elements!

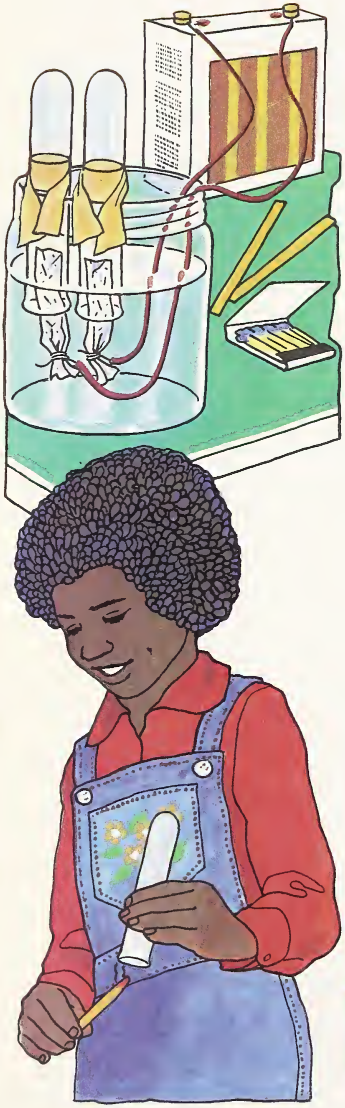
Another reason why there are many kinds of matter is that elements join together in different ways. When the elements hydrogen and oxygen are joined together in one way, they form water. When they are joined together in another way, they form a bleach used on hair.

Some matter joined in nature

When two or more elements join together, they form what is called a *compound*. Many compounds are found in nature.

The compound found most often in nature is water. For many years, people believed water was a single element. But it was discovered that water could be broken down into hydrogen and oxygen. These two elements are gases. They neither look nor act like water by themselves.

These chalk cliffs are known as the white cliffs of Dover, England. They are made of the compound calcium carbonate. What elements do you think make up the cliffs?



FINDING OUT

How can you break water down into its elements?

You will need: 6-volt battery or 4 dry cells, glass jar, 2 test tubes (or toothbrush cases), 2 pieces of covered wire, 2 pieces of aluminum foil, 2 wooden splints, 7 ml sodium sulphate (from a drugstore), matches, tape

- Fill the glass jar two-thirds full of water.
- Add the sodium sulphate to the water.
- Fill each test tube with water and invert them in the jar as shown. (Be careful not to get any air in the test tubes.) Tape the test tubes in place.
- Attach each piece of aluminum foil to the ends of the covered wire.
- Place the aluminum foil in the test tubes as shown.
- Connect the other ends of the wires to the battery.

What happens on the aluminum foil?
What changes do you see in the test tubes?

- Allow the test tubes to fill up with gas.
- Test the gases with glowing splints as shown.

Which splint bursts into flame? Why?
Which splint caused an exploding pop? Why?
(The chart on page 120 may help you answer these questions.)

Another common compound is salt. Salt was, for many years, also believed to be a single element. But it was discovered that salt could be broken down into the elements sodium and chlorine. Sodium is a silver-white, soft metal. Chlorine is a heavy, greenish gas. Atoms of these two elements join together to make salt for your supper table! As in all compounds, the elements which make up salt do not look or act like salt. How is salt different from its elements?

Another compound you most likely see often is rust. Rust may form on some cars. You may have seen rust on some bicycles. On what things have you seen rust?

Rust is made up of the elements iron and oxygen. Rust is a brittle, reddish-brown compound. How is it different from iron that you have seen? How is rust different from the oxygen that you breathe?

FINDING OUT

How can you get rust to form on objects?

You will need: small pieces of iron (steel wool, bobby pins, hair clips, safety pins, nails, or old metal toys will do); paper towel; glass

- Soak the paper towel in water.
- Wrap some pieces of iron in the towel.
- Place the rest of the iron in a glass of water.
- Each day, check on the pieces of iron. Be sure to keep the towel wet.

What happens to each piece of iron?
When do you first notice a change?
What element in the water helps make the new compound?
Why do you think rust is made on some things faster than on others?
What might you do to prevent iron objects from rusting?

While water, salt, and rust are made of just two elements, some compounds are made of more elements. One such compound is sugar. Carbon, hydrogen, and oxygen make up sugar. How are these things different from sugar?

Sugar is made by green plants. Most of the sugar used in homes comes from sugar cane and sugar beets. What are some things that are made with sugar?

Mixing metals

Many elements in the earth are called *metals*. Silver and iron are metals. Metals have certain properties which make them different from other elements. Many metals are hard and shiny. Most elements which are metals are most likely familiar to you. Which metals can you name?

Some metals found in the earth may be "pure." That is, they are found alone. They are not found mixed with other elements. However, some metals are often found mixed with other elements. Gold, for example, is found mixed with other elements. It has to be separated from these things to make it pure.

Lead Ore

Copper Mixed with Calcite

Even though metals are separated to become pure, most of the metal things around you are not made of pure metals. Things such as doorknobs and bicycles are made of several metals. These metals are called *alloys* [AL-OYZ]. An alloy is a combination of two or more metals. A metal alloy has properties that are different from each of its metals. What are some other things that are made of metals around you?

One common alloy is brass. Brass is made of copper and zinc. Copper is a soft, reddish-brown element. Zinc is a hard, whitish element. The colour and hardness of brass depend on how much copper is in it and how much zinc is in it. Brass that is made mostly of zinc is hard and bright. What would be some of the properties of brass if it were made mostly of copper?

The Romans made brass coins over two thousand years ago. Today, brass is used not only because of its hardness, but also because of its beauty. Lamp bases, trumpets, and jewelry are made of brass. What are some other things made of brass?

Probably the most common alloy used today is steel. Steel is made mostly of iron. Other metal elements, such as manganese or vanadium, may also be added.

Because of its strength, steel lasts for a long time. Some steel is used for making bridges and ships. Steel that is mixed with chromium may be used to make knives and forks. This steel is often called "stainless" steel. What are some other things around you which are made of steel? Why do you think this alloy is used more often than brass?

The gold used for rings and watches is not pure gold. The gold is often mixed with other metals. Pure gold is very soft. If a ring were made of pure gold, it would dent or bend out of shape. For what other reason might people not want to buy something made of pure gold?

Building "new" matter

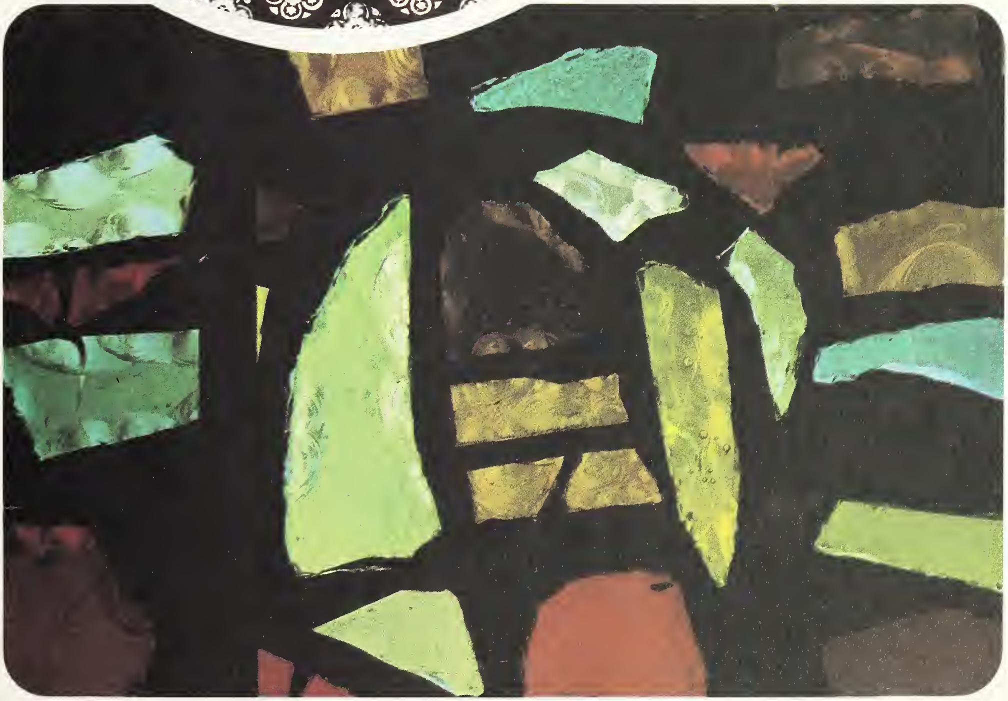
As brought out, some of the things you use each day are found in nature. Salt and water are such things. There are also many other things you use which are found in nature. A tree may be cut down and made into a wooden table. Parts of cotton plants can be used to make shirts or coats. What are some other things which are made from things in nature?

Many of the things you use each day, however, are not found in nature. What are some things around you which are not found in nature?

The cotton from this plant can be spun into cotton threads. What things do you have that are made from cotton threads?

Glass. Imagine a house with no windows! Think of a car with no windshield! Can you think of glasses with no lenses? What things do you use that are made of glass?

Glass is made of just four elements. They are silicon, oxygen, sodium, and calcium. Silicon, you may remember, is a common element in the ground. Sodium and calcium are light metals which also can be found in many places in the ground. Each of these four elements are then mixed and heated to make glass. How do you think glass can be made into so many shapes?



These windows are made of stained glass. In what ways is a stained glass window different from most other windows? How do you think stained glass windows are made?

Exploring on Your Own

Detergents are often used to clean things. How are detergents different from soap? What are some common detergents?

Soap. Another common kind of matter is soap. Soap is not made in nature. For thousands of years, people had to wash themselves and their clothes in just water. Some people rubbed gravel or sand on their skin and clothes to help get the dirt out!

The first soaps were made from animal fats and lye. Lye is a compound of sodium, hydrogen, and oxygen. People would put these things in a large pot and boil them. Today, soaps are made in much the same way. Vegetable oils and a compound of potassium, hydrogen, and oxygen are mixed and boiled to make soap.

Plastics. Perhaps one of the most common kinds of "new" matter that you see and use is plastic. Plastics are used in place of many kinds of matter that are found in nature. This is true for several reasons. One reason is that plastics are often less expensive. A shirt made of plastic thread often costs less to make than one made of cotton or wool thread. Things made of plastics can also be made as strong as many metal things. For this reason, the bodies of some cars are made of plastics.

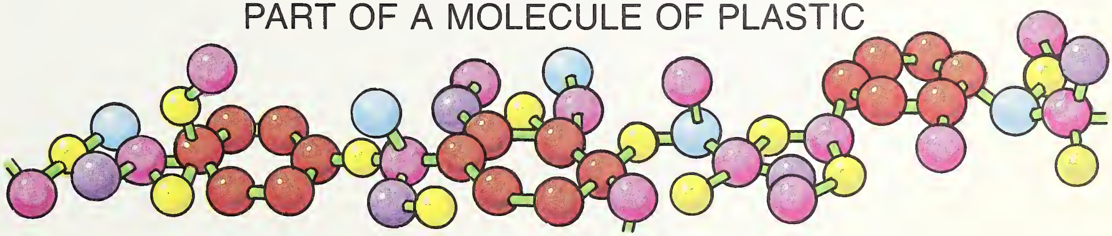
Another reason why plastics are used instead of natural elements is colour. Plastics can be made any colour. Plastics can also be made to look like many things found in nature. They may look like wood, stone, and even diamonds!

Most plastics are made of just four common elements. They are carbon, hydrogen, oxygen, and nitrogen. The atoms of these elements are joined together like links of a chain. These "chains" of atoms are then linked with other chains to make huge molecules. The molecules of plastic can then be formed into many kinds of plastic matter.

The pictures on page 138 show some things made of plastic. How is each of these things different from the elements used to make them?

For You to Think About

Why do you think people make plastic to look like wood or glass? How might these plastics be used?



PART OF A MOLECULE OF PLASTIC

FINDING OUT

How can you make a display of plastics?

You will need: old magazines, newspapers, scissors

- Search through the magazines and newspapers for pictures of things made of plastic. Cut out each picture.
- Make a display of each picture on a bulletin board or in a scrapbook.

What are the uses of each plastic?
What are the special properties of each plastic?
Why do you think each of these things is made of plastic instead of another kind of matter?

- Make a display of objects made of plastic.

What things in your school and home are made of plastic?

A Second Look

1. How can just a few elements make up billions of kinds of matter?
2. What is a compound? What are some compounds found in nature?
3. What is an alloy? What are some common alloys?
4. What are some kinds of matter that are not found in nature?

One of the most useful groups of elements in the earth is the metals. The people who work with metals are called *metallurgists* [MEHT-uhl-UR-juhsts].

The job of some metallurgists is to look for areas of the earth which have certain kinds of metals. Once these metals are found, the metallurgists' job is to get the metals out of the earth. Mines are often dug deep into the earth to get to these metals. These metallurgists also find ways to separate the needed metals from other elements.

Other metallurgists work with pure metals. By mixing these metals, new alloys are made. These metallurgists might want to make a strong alloy that would make good bumpers for cars. They might want to make a strong alloy that would be light enough for a racing bicycle.

Metallurgists have learned many things about metals and their alloys. Dimes and quarters were once all silver. Metallurgists have learned cheaper ways of making coins. These coins are now made with a layer of copper.

To find out more about metallurgists, try to find answers to the questions:

How do metallurgists know where to look for certain kinds of metals?

How do metallurgists separate pure metals from other elements?

How do metallurgists test different alloys for strength? Elasticity? Brittleness?

For answers to these questions and others you might have about metallurgists, you might write to the Canadian Institute of Mining and Metallurgy, 906 - 1117 St. Catherine Street West, Montreal, Quebec H3B 1J3.

A metallurgist may often study metal samples in a mine before they are taken out of the earth. Why do you think this is so?

Reviewing the Main Ideas

Some common properties of matter are impenetrability, inertia, mass, weight, volume, and density.
Some special properties of matter are brittleness, colour, elasticity, and conductivity.
All matter is made up of molecules.
Molecules are made up of atoms.
An element is matter that is made of only one kind of atom.
A compound is two or more elements joined together.
An alloy is two or more metals joined together.
Some compounds can be found in nature. Other compounds can be made by people.

Reading About Science

Adler, Irving. *Atomic Energy.* Don Mills, Ontario: Fitzhenry & Whiteside Ltd., 1971.
Asimov, Isaac. *How Did We Find Out About Atoms?* Pickering, Ontario: Beaverbooks, 1976.
Gaines, Mathew. *Atomic Energy.* Georg Zappler, ed. Don Mills, Ontario: Fitzhenry & Whiteside Ltd., 1973.
Haines, Gail Kay. *Elements.* Toronto, Ontario: Grolier Ltd., 1972.
Hyde, Margaret O. *Atoms Today and Tomorrow,* 4th ed. Scarborough, Ontario: McGraw-Hill Ryerson Ltd., 1970.

Testing for Understanding

Ideas to Check

On your paper write *T* for each sentence below that is true. Write *F* for each sentence that is false.

1. Inertia is a common property of matter.
2. Mass is a special property of matter.
3. Density is the amount of mass in a certain volume.
4. Molecules cannot be divided into smaller parts.
5. You can see atoms without using a microscope.
6. Alchemists were able to turn iron into gold.
7. Nitrogen and oxygen are the elements which make up most of the air.

Words to Use

Write on your paper the word that best fits in each blank below. Choose from these words: *alloy, aluminum, colour, electrons, element, iron, neutrons, oxygen, protons, volume, water.*

1. A common property of matter is ——.
2. A special property of matter is ——.
3. Matter that is made of only one kind of atom is called an ——.
4. An —— is a combination of two or more metals.
5. —— is a compound made of oxygen and hydrogen.
6. Rust is a compound made up of the elements —— and ——.

Having Fun with Science

Guessing Properties

Play a guessing game with a group of people. One person thinks of a kind of matter. Others try to guess what it is. However, only yes-no questions about its properties can be asked. Such questions might be: Is it brittle? Can it bend? Can it pour?

Clues for a Detective

The clues given below are about the names of some elements. See if you can figure out what the names of these elements are.

Used in many thermometers.
Named for a man and his prize.
Used on cuts and bruises.
Put in swimming pools.
Found in your bones and teeth.
Lights up the town.
Braces for straightening teeth.

Reading the Labels

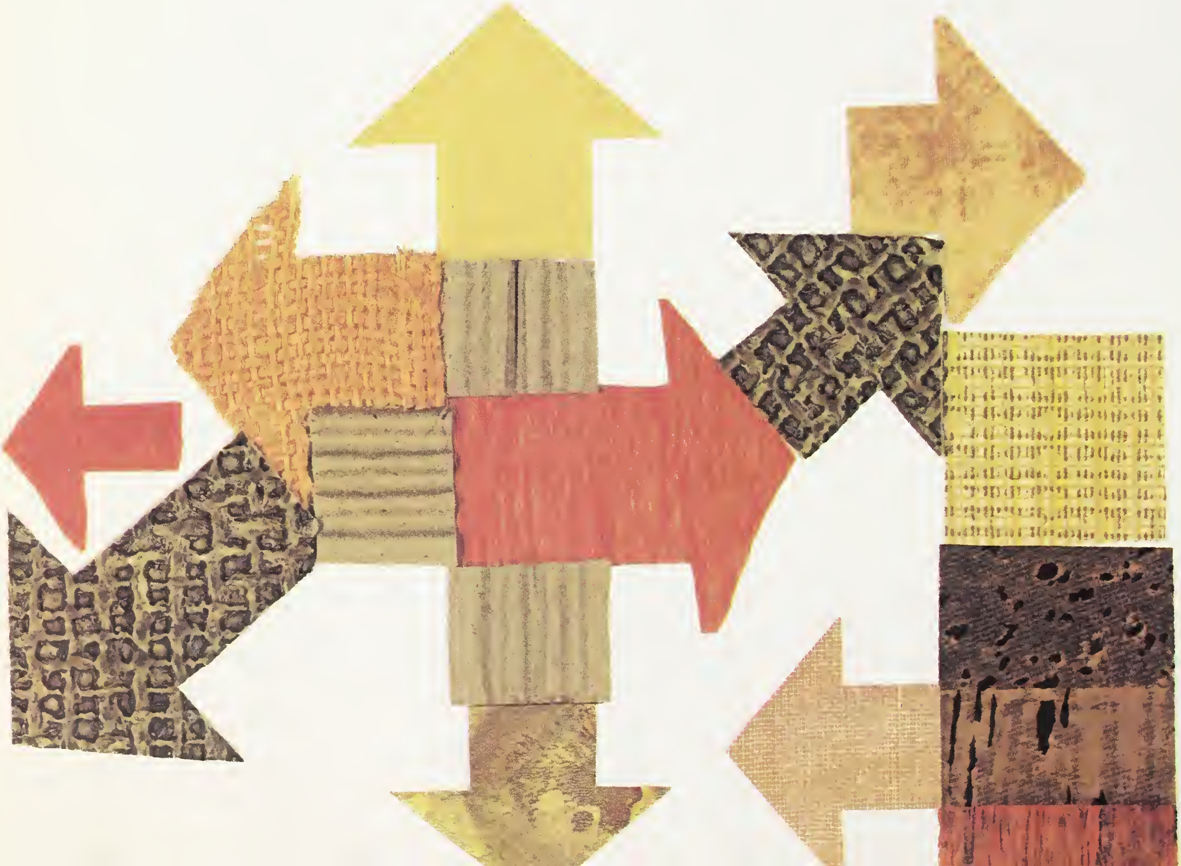
Cans and packages of food have labels which list their contents. Besides the food, many additives are also in each package. Visit a food store and read the labels of such things as cereals, candy, frozen dinners, and soda pop. What are the additives?

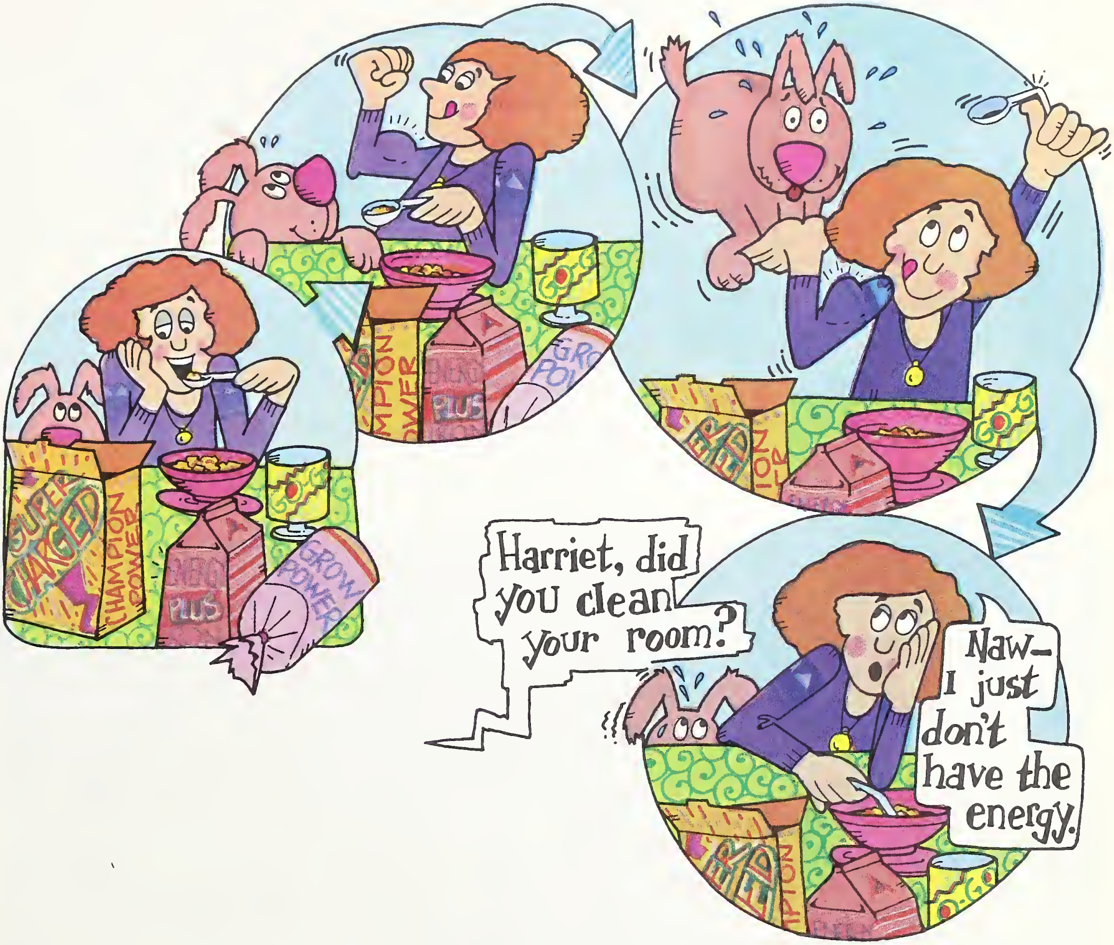
News Broadcast

You are a famous scientist who has just discovered a new element. Make up a statement for radio, TV, and the newspapers. Be sure to include such things about your element as its name, where found, how found, its properties, and its uses. Also tell what happens when it joins with other elements.

4 Changes in Energy

1 **Some kinds of energy**
2 **Capturing energy**
3 **Energy in your future**




SUPER CHARGED
CHAMPION POWER
PLUS
GROW POWER
Harriet, did you clean your room?
Naw— I just don't have the energy.

What do you think energy is?

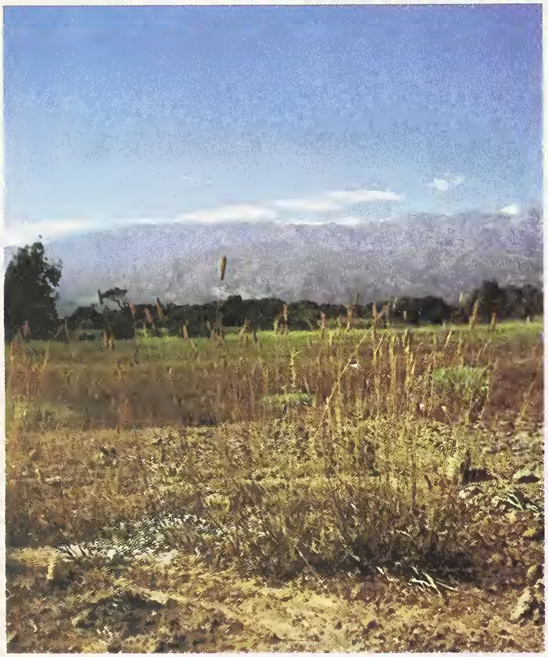
When have you felt "full of energy"?

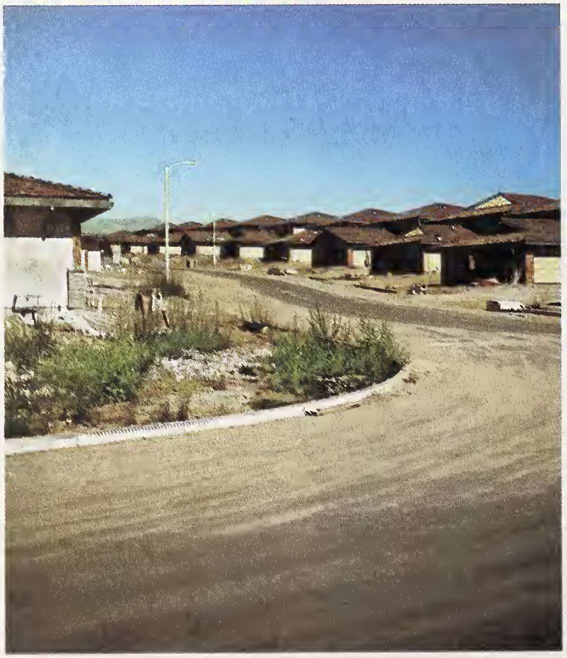
What things besides people need energy?

1 Some kinds of energy

There are millions of different kinds of matter around you. But all these different kinds of matter are alike in some ways. One way in which all matter is alike is that it can be changed. Some changes in matter take place very slowly. A mountain may take millions of years to form. Some changes in matter take place very quickly. For example, many people can change a stick of gum into a wad of gum in just a few seconds! What are some other changes in matter that take place very quickly?

Whenever matter changes, the change is brought about by *energy* [EHN-ur-jee]. Energy is the ability to cause change. Energy causes ice to melt. Energy causes things to move. Energy even causes you to grow taller!





Chemical energy

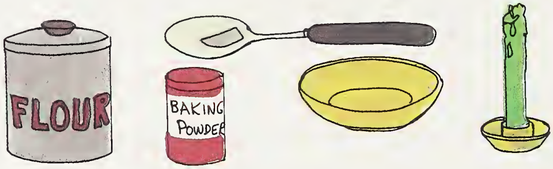
There are many different kinds of energy. Each kind of energy plays an important part in your life. One kind of energy is *chemical* [KEHM-ih-kuhl] *energy.* There is chemical energy in the food you eat. The food you eat is changed in your mouth, stomach, and other parts of your body. The changed food is then used by your body. It is used for energy to do such things as running, growing, and even thinking! For what other things does your body use chemical energy from the food you eat?

There are many other things besides food which have chemical energy. Paper, wood, coal, and gasoline have chemical energy. When these things are burned, chemical energy in them is released. How might chemical energy from each of these things be useful to people?

FINDING OUT

How is chemical energy important in making bread?

You will need: 15 mL flour, 5 mL baking powder, large spoon with wooden handle, candle, small bowl



- Mix the flour and the baking powder in the bowl.
- Add enough water to make dough.
- Place the mixture in the spoon.
- Hold the spoon over a lighted candle.
  Heating the mixture will release chemical energy, causing bubbles of carbon dioxide to form.
- Watch your "bread" in the spoon.

What happens to the bread? Why?
Find a recipe for homemade bread. Try making some.

Mechanical energy

Chemical energy can be changed into other kinds of energy. For example, chemical energy can be changed into *mechanical* [mih-KAN-ih-kuhl] *energy*. Mechanical energy is energy of motion. Whenever something moves, it has mechanical energy. Do you think all matter can move? Why or why not?

Mechanical energy from chemical energy. As you may remember, there is chemical energy in the food you eat. This food is slowly "burned" in the cells of your body. When food is burned in the cells of your muscles, energy is released so that your muscles can move. So, whenever you run or just scratch your arm, you are using mechanical energy. In what other ways do you move your body?

Chemical energy from burning fuels can also be changed into mechanical energy. Gasoline-burning engines are used to run most cars, trucks, and buses. In what ways can the mechanical energy from cars, trucks, and buses be helpful to you?

Forms of mechanical energy. Mechanical energy is often thought of as having two forms. One form is *potential* [puh-TEHN-chuhl], or stored, energy. A ball sitting at the top of a hill has potential energy. The second form of mechanical energy is *kinetic* [kuh-NEHT-ihk], or moving, energy. A ball rolling down a hill has kinetic energy.

Think of the last time you stretched a rubber band. After the rubber band was stretched, it had potential energy. When you let it go, the potential energy of the rubber band changed to kinetic energy. What are some other examples of changes between potential and kinetic energy?

Vibrating matter. As brought out, mechanical energy is energy of motion. When some things move, they *vibrate* [VY-brayt]. When something vibrates, it moves quickly back and forth. When something vibrates quickly enough, a sound is made. So, sound can be thought of as a kind of mechanical energy. What are some things around you that make sound?

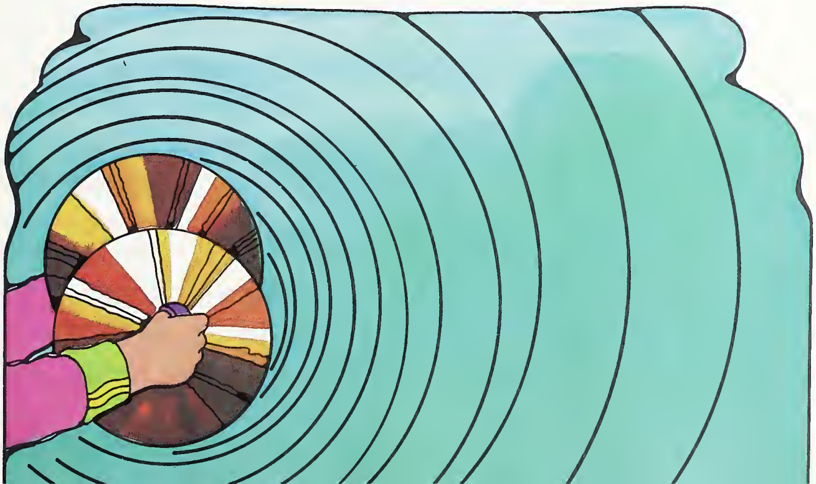
When something vibrates, the air around it also vibrates. In this way, the vibrations travel through the air. Sound vibrations in air travel in "waves," called *sound waves.* The drawing on this page shows how sound waves travel through the air.

As sound waves travel to you, your ears can "pick up" the vibrations. This causes certain parts of your ears to vibrate. Nerves then send messages about these vibrations to your brain. You then can understand what the sounds are.

Sounds can be an important part of your life. Some sounds may warn of danger. These sounds can help you be safe. What might some of these sounds be? In what other ways is sound important to you?

For You to Think About

Some people think that there can be no sound unless someone is there to hear it. Do you think this is true? Why or why not?



Heat energy

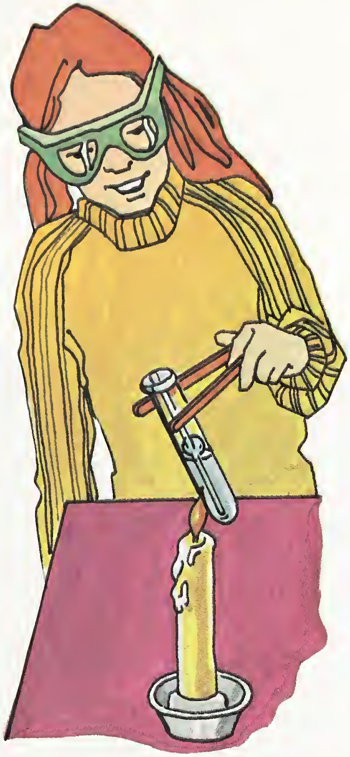
Another kind of energy is *heat energy*. You can often feel heat energy. When there is a lot of heat energy in the air, you may feel warm. When there is very little heat energy in the air, you may feel cold. When have you felt a lot of heat energy in the air? When have you felt very little heat energy in the air?

Heat energy from mechanical energy. Sometimes heat energy can be made from mechanical energy. When matter is in motion, it sometimes rubs against other matter. When matter rubs against other matter, heat is made. You can feel heat when you rub your hands together. If you rub your hands faster and harder, you will make more heat. When else can you feel heat from things rubbing together?

Heat energy from chemical energy. Heat energy can also be made from chemical energy. As you may remember, chemical energy from the food you eat can be changed into mechanical energy. This happens whenever you move. This chemical energy can also be changed into heat energy. This is what gives you your body heat. What is the temperature of your body? What are some things that might cause your body to become warmer?

Burning is another example in which chemical energy is changed into heat energy. When have you felt heat from something that was burning?

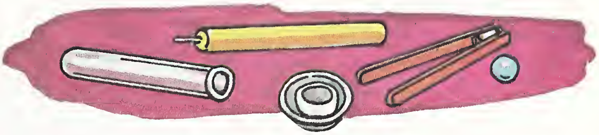
When you feel heat energy, it may be coming from many different things. What are some things which give off heat energy? In what ways do you think heat energy is helpful to people?



FINDING OUT

How can you cause changes in energy?

You will need: candle, test tube, marble, clamp



- Half fill the test tube with water.
- Place the marble in the test tube.
- Using the clamp, hold the test tube over the flame as shown. Be sure the test tube is not pointing toward anyone.

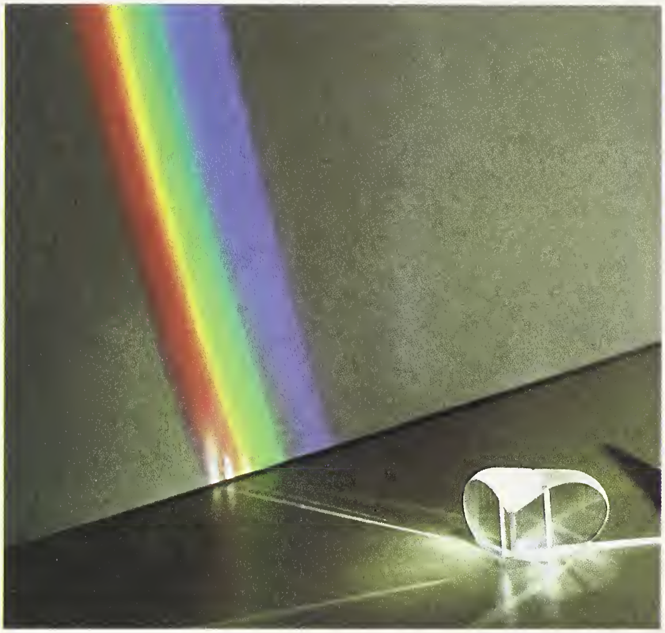
What happens to the water inside the test tube? Why?
What happens to the marble? Why?
What kinds of energy were changed in this activity?
Explain how energy changed from one kind to another.

Radiant energy

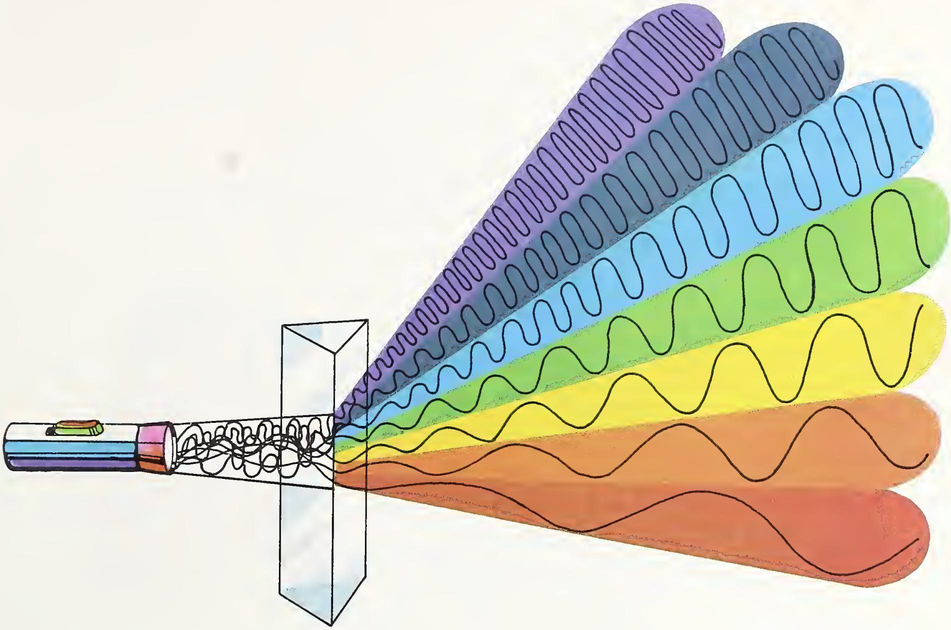
Still another kind of energy is *radiant* [RAYD-ee-uhnt] *energy*. Radiant energy has different forms. One of these forms you know as light. In what ways is light important to you and other living things?

Seeing the light. Usually, when energy travels to you from its source, something carries it. Sound and heat are carried by air or by objects. But light energy is different. Light energy, such as light from the sun, can travel through empty space. In fact, no one is quite sure how light energy travels.

A narrow path of radiant energy is often called a *ray*. A ray of light can be broken down into many colours. This happens when the light passes through a *prism* [PRIHZ-uhm]. Look at the picture on this page. What are the colours of light coming from the prism?



Many people believe that light is made up of tiny bits of energy. These bits of energy move as tiny waves. A ray of light is made up of waves of different lengths. Each colour in light has its own wavelength.



The picture on this page shows the wavelengths of different colours. How are the wavelengths different? Which colour has the longest wavelength? Which colour has the shortest wavelength?

When the light waves pass through a prism, they bend. The red waves bend the least. Each of the other colour waves bends a little differently. The violet waves bend the most.

Below the red. Besides light, there are other kinds of radiant energy. However, these kinds of radiant energy are invisible, or cannot be seen. Some of these kinds of radiant energy have wavelengths that are longer than the wavelengths of light.

Exploring on Your Own

People sometimes refer to light as visible light or white light. Find out what is meant by visible light or white light. Library books about colour or light may be helpful to you.

In the year 1800, an English scientist named William Herschel tried an experiment using light energy. He knew that light energy can be changed into heat energy. But he wondered whether certain colours would heat a thermometer more than others.

Herschel blackened the bulb of a thermometer. He placed the thermometer in each colour formed by a prism. First he placed it in the violet end. Then he moved it, colour by colour, toward the red end. In each colour, the temperature rose slightly.

Then Herschel placed the thermometer just outside, or below, the red colour. To his surprise, the temperature rose higher still! He discovered a band of invisible waves. These invisible waves are known as *infrared* [IHN-fruh-REHD] *waves,* because infra means below.

Infrared waves are often called *heat waves* because they heat things so well. But the heat comes about only when the waves hit an object. There are many things which give off infrared waves. The sun, electric bulbs, broilers, and heat lamps all give off strong infrared waves.

The reddish bulbs in this picture are giving off infrared waves. Why might these waves be important to the baby chickens? What might be some other uses of infrared waves?

A person's body also gives off infrared waves. Have you ever been in a room filled with people? If so, you know that the temperature of the room may rise. Why do you think this is so?

FINDING OUT

How can you feel "heat waves"?

You will need: pieces of different-coloured construction paper

- Hold the palms of both hands very close to your face. Feel the heat given off by your hands.
- Have other people hold their palms close to your face.

Which palms gave off more heat waves than others? What things might cause some palms to give off more heat waves than other palms?

- Set up the pieces of coloured construction paper in a row. Be sure the same amount of light shines on each piece of paper.

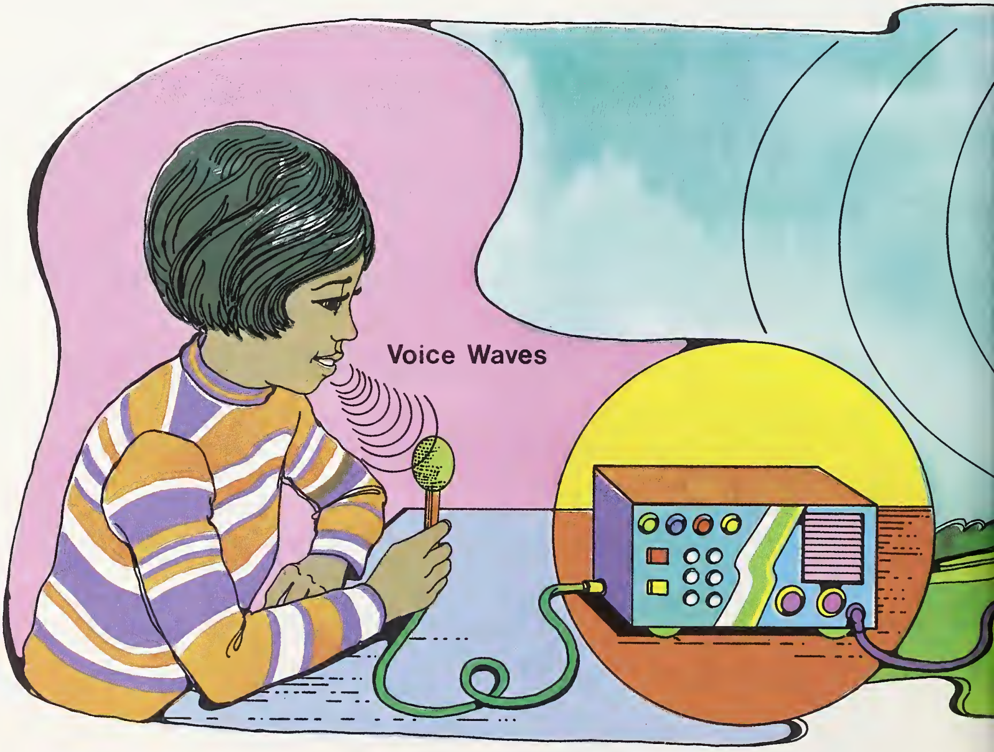
Which colour do you think will give off more heat waves? Why?

- With your eyes closed, have someone move your hand close to the different colours, one by one.

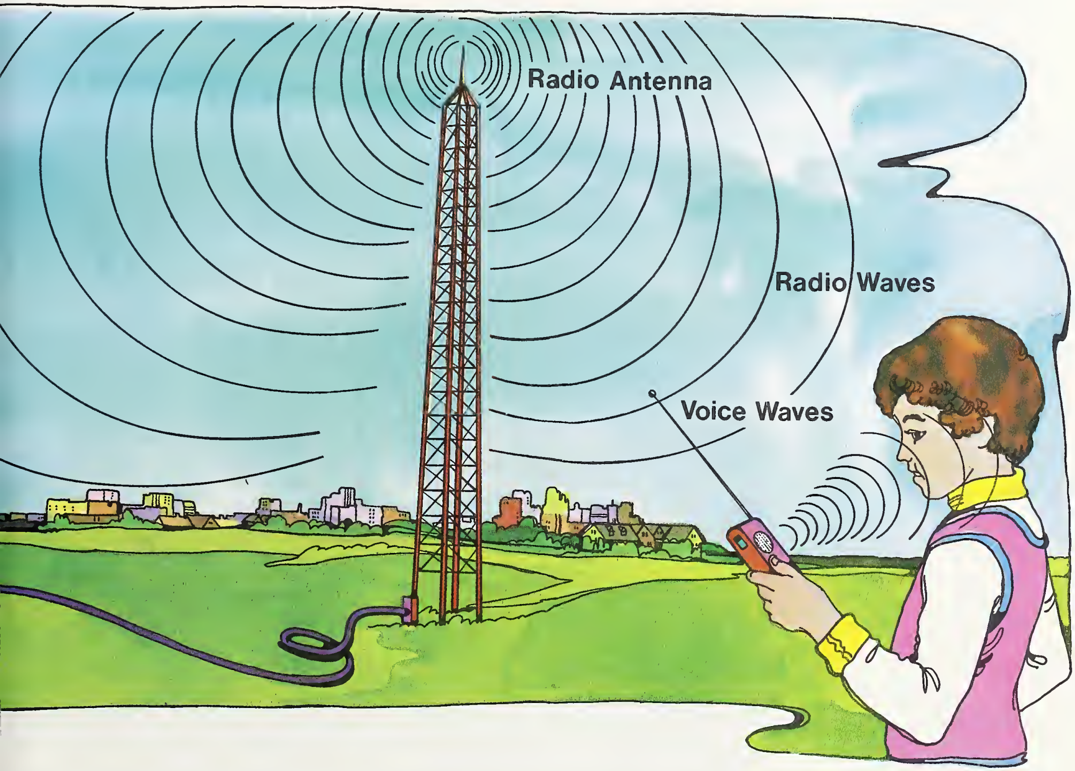
Did some colours give off more heat waves than others? Explain your results.

Radio waves. Another form of radiant energy which cannot be seen is *radio waves.* Sound energy is changed into radio waves at a radio station. Radio waves are sent out in all directions from a radio station. A tuned-in radio can "pick up" some of these waves and change them back into sound. The picture below and on the next page shows how this happens.

Radio waves can travel much farther than voice waves. How far can your voice waves travel? From how far away do your favourite radio programs travel to you?



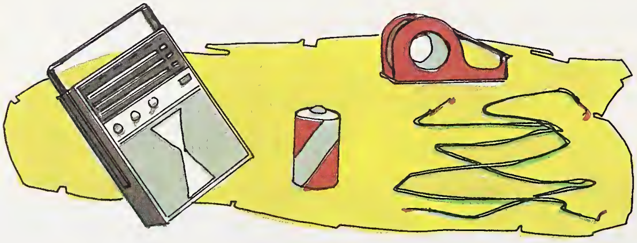
Television programs are brought to you in much the same way as radio programs. The sounds from your television come from radio waves. There is also a camera which changes light energy to electricity. The electricity is changed to special radio waves. These waves are then sent through the air. Your TV can then pick up these waves in your home. The television tube then changes these energy waves back to light energy. In this way you can see a program. How are radio and television important to you?



FINDING OUT

How can you make radio waves?

You will need: short piece of bell wire, portable radio, flashlight battery, tape



- Bare each end of the wire.
- Tape one end of the wire to the bottom of the battery as shown.
- Turn on the radio. Set the dial between stations so there is no sound. Be sure the volume is turned up.
- Hold the battery and wire close to the radio.
- Touch the free end of the wire to the battery's top knob. Quickly draw it away.

What do you hear?
What do you see?

- Continue brushing the wire end on the battery knob.
- Have someone hold the radio and walk away to find out how far your "broadcast" can be sent.

How far away can you send your broadcast?
In what ways might the way the radio is facing change the broadcast? Try finding out.

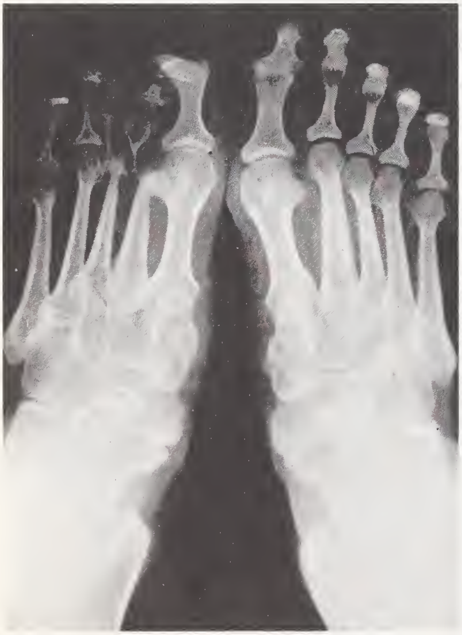
Ultraviolet waves. As you may remember, infrared waves and radio waves are longer than light waves. There are some waves of radiant energy that are shorter than light waves. One kind is known as *ultraviolet* [UHL-truh-VY-uh-luht] *waves*. Ultraviolet waves are also invisible.

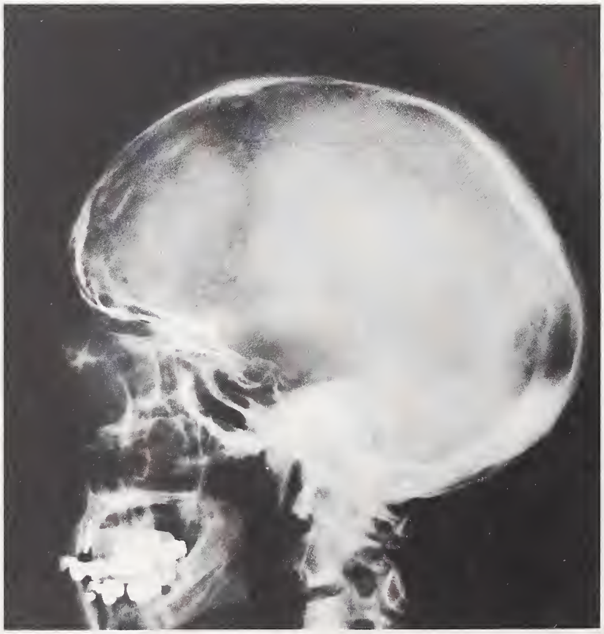
There are different sources of ultraviolet waves. Some ultraviolet waves come from the sun. It is these waves which can tan or burn a person's skin. Ultraviolet lamps are often used in hospitals to kill germs. Long exposure to ultraviolet waves can be dangerous to a person. In what ways might this be so?

Fluorescent lamps, which give off ultraviolet waves, are sometimes used to grow plants. In this way, plants can be grown where there is no sunlight. Why might this be important?

Shorter waves. There are waves of radiant energy that are even shorter than ultraviolet waves. Some of these waves are known as *X rays.* X rays can pass through parts of your body to make X-ray pictures. Look at the X-ray pictures shown on this page. What things do they show? Why do you think X-ray pictures are important to people?

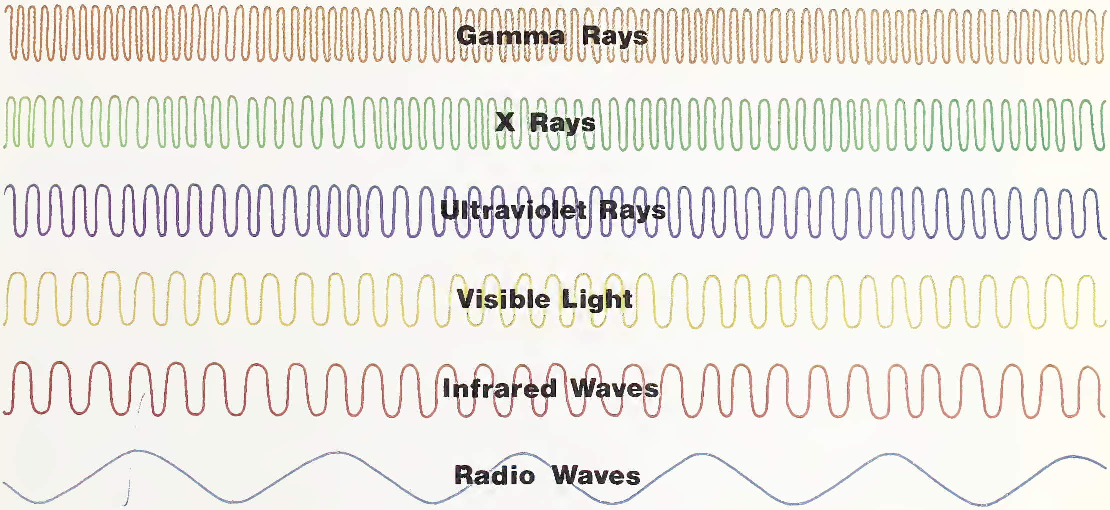
Some shortwave X rays can be used to kill harmful cancer cells in the body. But X rays can also be harmful. Long exposure to X rays may cause healthy cells in the body to become damaged. People who use X-ray machines must protect themselves from this. How do you think people who use X-ray machines protect themselves from long exposures?





Some shorter and more powerful waves than X rays are called *gamma* [GAM-uh] *rays.* Gamma rays are often used to kill cancer cells deep within a person's body. These rays can even pass through thick metals. When might people want to use rays that can pass through metal?

COMPARING WAVELENGTHS OF RADIANT ENERGY



The drawing above represents the wavelengths of different kinds of radiant energy. Which kind of energy has the longest wavelength? The shortest wavelength?

A Second Look

1. What are some different kinds of energy?
2. What are some forms of radiant energy?
3. What are some examples in which one kind of energy can change into another kind of energy?

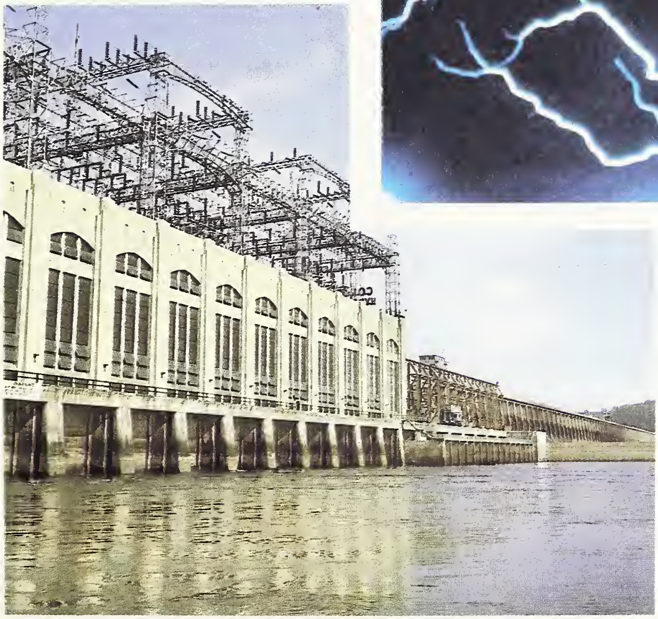
2 Capturing energy

Many kinds of energy affect you directly every day. Light energy enters your eyes so that you can see things around you. Sound energy enters your ears so that you can hear things. Chemical energy from the food you eat not only helps you grow but also helps you move and keep warm. These kinds of energy have been a part of people's lives for millions of years.

There are other kinds of energy which have always been around people. These kinds of energy, however, were not used for a long time. People had to learn how to "capture" them.

Electrical energy

One kind of energy that has been around people for a long time is *electrical* [ih-LEHK-trih-kuhl] *energy*. Thunder and lightning from storms are caused by electrical energy. However, to make use of this kind of energy, people have had to develop ways of making it.

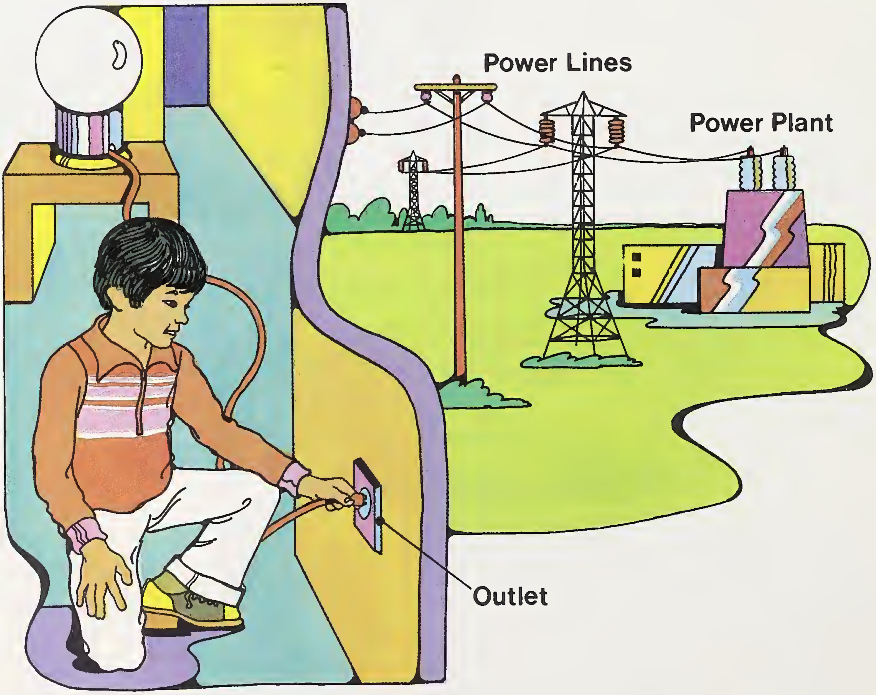


One way people can make electricity is by using the force of flowing water. The water shown in this picture will flow through the dam and generate electricity. How do you suppose the electricity will get to cities and towns?

Electricity. Electrical energy is most commonly known as *electricity*. Radios, TV's, hair dryers, refrigerators, lamps, and electric toothbrushes are run by electricity. What are some other things which are run by electricity?

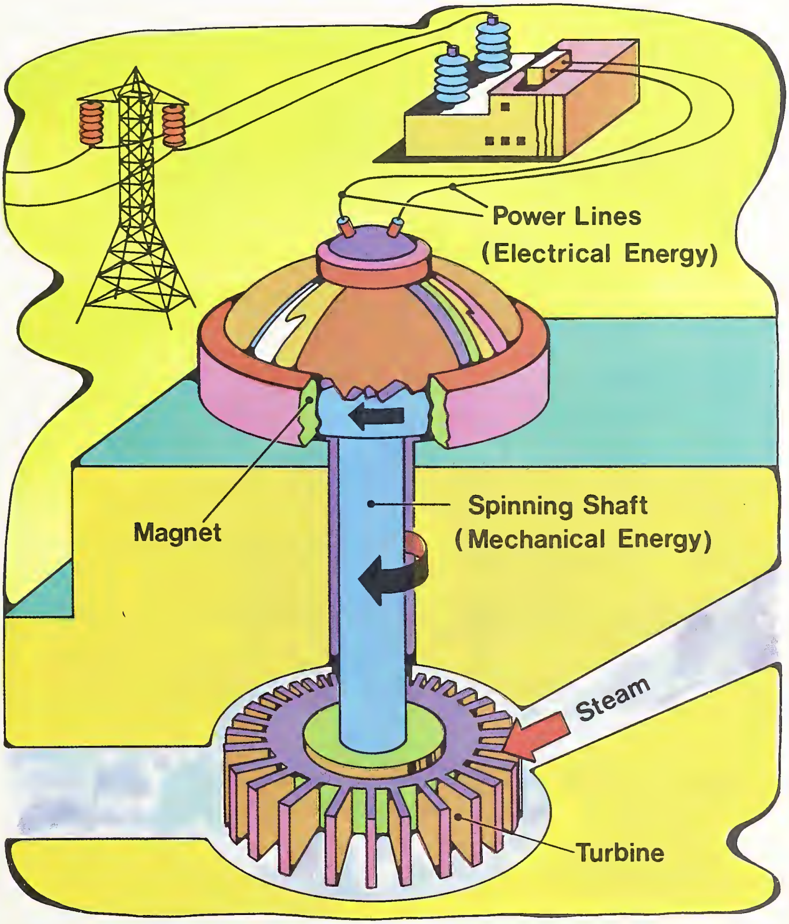
When you plug in a radio or a lamp, you are not capturing energy from a thunderstorm. You are getting energy from electricity that runs through wires. These wires run from outlets in your home or school to electrical power lines outside. These power lines, in turn, are connected to an electrical power plant, where electricity is made.

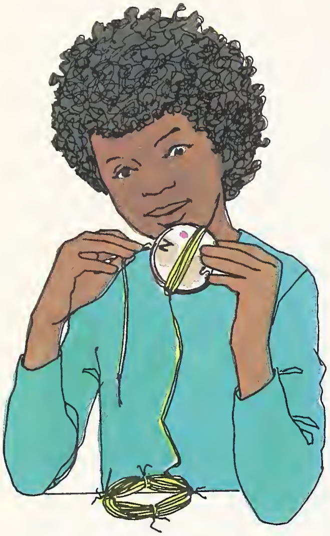
HOW ELECTRICITY GETS TO YOUR HOUSE



In an electrical power plant, electrical energy is made from mechanical energy. This is done by a machine called a *generator* [JEHN-uh-RAYT-ur]. The picture on this page shows how a generator changes mechanical energy into electrical energy.

HOW A GENERATOR WORKS





FINDING OUT

How can you show how an electric generator works?

You will need: about 12 m of bell wire, thread, compass, strong magnet, paper cup

- Bare the ends of the bell wire.
- Wrap the bell wire about fifty times around the paper cup to make a coil.
- Slip off the coil and fasten it with thread so the coils won't come apart.
- Wrap the rest of the wire about twenty times around the compass as shown. The compass will act as an electric current detector.
- Connect the bare ends of the bell wire. Your magnet and coil will work somewhat like an electric generator.
- Hold the magnet still and move the coil over one end of the magnet.

What happens to the compass needle? Why?

- Remove the coil by sliding it back.

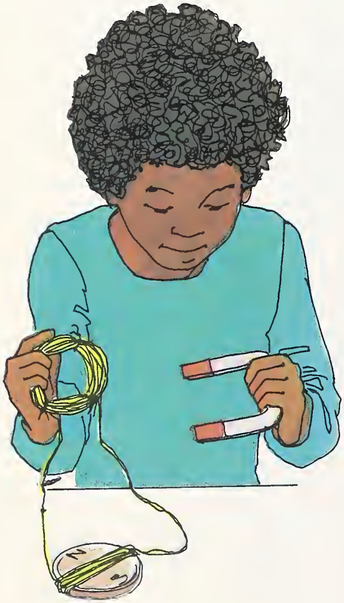
What happens to the compass needle? Why?

- Move the coil over the other pole of the magnet.

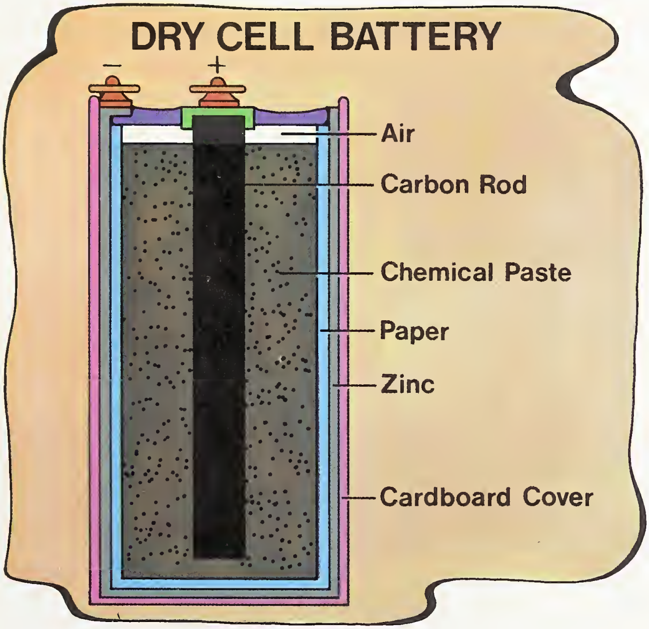
What happens to the compass needle? Why?

- Hold the coil still and move the magnet in and out of the coil.

What happens to the compass needle? Why?
What do you think will happen if you move the magnet faster? Why? Try it.
What mechanical energy is used in this activity?



Electrical energy can also be made from chemical energy. The electricity which runs flashlights and portable radios comes from chemical energy. This chemical energy comes from *batteries.* The picture on this page shows the inside of one kind of battery. What are some things you have used that are run by batteries?



Changes in electrical energy. Electrical energy can be changed into other kinds of energy. Many stoves and ovens change electrical energy into heat energy. A light bulb can change electrical energy into light energy. Electricity can be changed into many other kinds of energy. What kinds of energy might these be?

Nuclear energy

Another kind of energy which can be captured from nature and used by people is *nuclear* [N(Y)OO-klee-ur] *energy.* Nuclear energy comes from the center of an atom. The centre of an atom is called the *nucleus* [N(Y)OO-klee-uhs]. So, nuclear energy gets its name from this centre.

Nuclear energy comes about when there is a change in the nucleus of an atom. This change may be a very slow change which happens in nature. Or, it may be a very fast change caused by people.

Radioactive matter. The slow change in a nucleus takes place in only a few kinds of matter. These changes take place in matter that is *radioactive.* One such radioactive matter is the element *radium* [RAYD-ee-uhm]. Radium loses some of the parts of its nucleus in the form of energy rays.

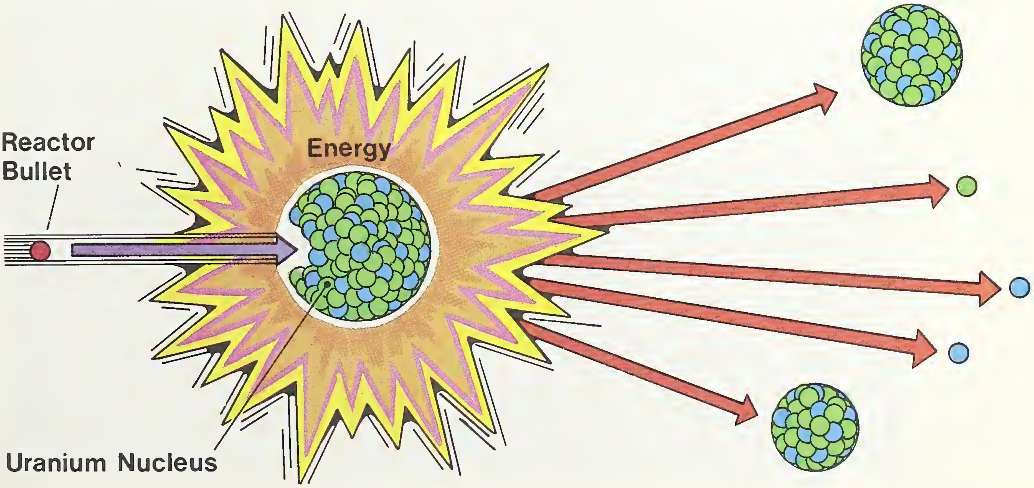
After the discovery of radioactivity, Marie Curie, pictured at the right, became interested in studying radiation. She and her husband, Pierre, discovered the element radium in uranium ore. They received Nobel prizes for their research of radioactive elements.

The rays of energy given off by radium are very powerful. People have been able to capture and use these energy rays in a helpful way. They can be used to treat some diseases, such as cancer. Sometimes, however, these rays can be dangerous. When a person is exposed to these energy rays for a long time, they can be harmful. Why do you think this is so?

Nuclear reactors. People can also capture nuclear energy by using a *nuclear reactor*. A nuclear reactor is made up of many special instruments. These instruments are used to split apart the nucleus of an atom.

The nucleus of an atom is made up of many particles. The particles in a nucleus are held tightly together. When the nucleus is split apart, enormous amounts of energy are given off. A nuclear reactor can control the

SPLITTING OF A URANIUM NUCLEUS



energy that is given off. It must be controlled so that a lot of energy is not given off all at once. Why might a lot of energy given off all at once be dangerous?

Much of the energy given off from a nuclear reactor is heat energy. This heat energy can be used to heat water to make steam. The steam can then be used to run an electric generator. For this reason, nuclear reactors are built in many places around the earth to make electricity for millions of people.

Nuclear energy is also used to run some ships. This energy is used to make steam. This steam is then used to power the engines. By using nuclear energy, these ships may stay at sea for many months with only a small amount of fuel.

The nuclear submarine pictured below is able to generate electricity from nuclear power. This nuclear power also provides enough energy for the submarine to travel completely around the earth before coming to the surface. Why do you think this might be important?

Solar energy

The oldest known source of energy is the sun. Energy from the sun is called *solar* [SOH-lur] *energy*. Solar energy can be seen as light energy. It can be felt as heat energy. Or, solar energy can be captured and changed into other kinds of energy.

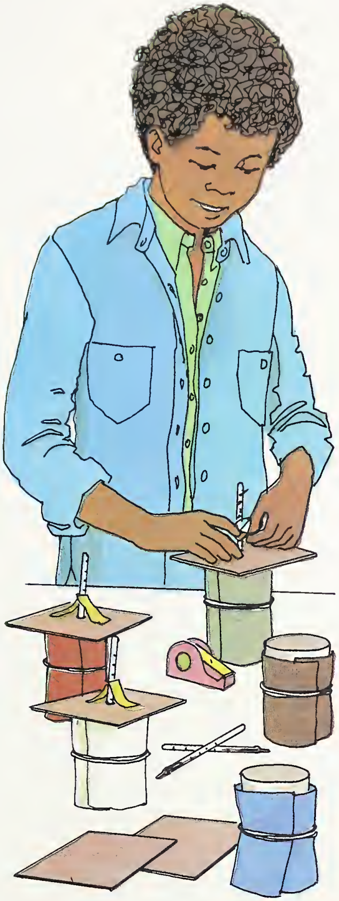
Absorbing heat energy. Have you ever got into a car on a sunny day? If so, you know that the inside of a car can become very warm. A car can *absorb*, or soak up, solar energy. This solar energy changes into heat energy. If the doors and windows are closed, the heat is trapped inside the car. The heat energy may stay in the car long after the sun has set.

Solar energy is often trapped in greenhouses in this way. Greenhouses are buildings used to grow plants. Sunlight shines through the glass roof of greenhouses. The sunlight heats the air inside. So, sunlight is changed into heat energy. Why do you think greenhouses are built to absorb heat energy?

Builders often think of solar energy when they build homes and other buildings. Many buildings have large, double glazed windows facing to the south, and smaller windows facing north. Some have solar collecting panels as part of the walls or roof. Why do you think these buildings are built in these ways?

Chemical energy from solar energy. Solar energy can be changed into chemical energy. One place this happens is in green plants. Green plants make their own food. To do this, they need sunlight. In making food, plants store the sunlight in them as chemical energy.

Besides flowers, what other kinds of plants might be grown in greenhouses such as these?



FINDING OUT

How does colour affect heat absorption?

You will need: 5 thermometers, 5 empty cans of the same size, gray paper, black paper, red paper, white paper, coloured paper of your choice, 5 rubber bands, cardboard for can covers, measuring cup, tape

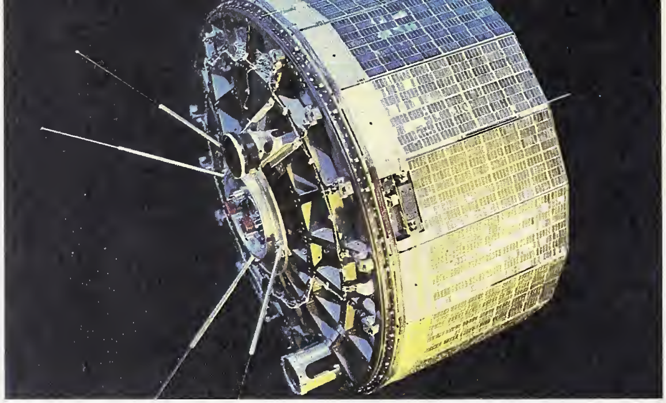
- Wrap each can with different-coloured paper. Use the rubber bands to hold the paper in place.
- Using the measuring cup, pour an equal amount of cool water into each can.
- Tape the thermometers through the covers of each can, as shown. Make sure the thermometers do not touch the sides or bottoms of the cans.
- Record the temperature of each thermometer.
- Place each can in bright sunlight.

Which colour do you think will absorb the most sunlight? Why? The least? Why?

- Take temperature readings every fifteen minutes for about two hours.

In which can has the temperature changed the most? Why? In which can has the temperature changed the least? Why? How did the temperature in the can with the paper you chose compare with the other four?

When you eat food made from green plants, you are getting solar energy which has been stored chemically by the plants. How is this chemical energy important to you?



This satellite has open panels through which sunlight can be absorbed into its solar battery. The battery makes electricity for sending radio messages back to the earth. What do you think these messages might be about?

Electrical energy from solar energy. Solar energy can also be changed into electrical energy. This change takes place in solar batteries. These batteries are different from the ones used in flashlights and cars.

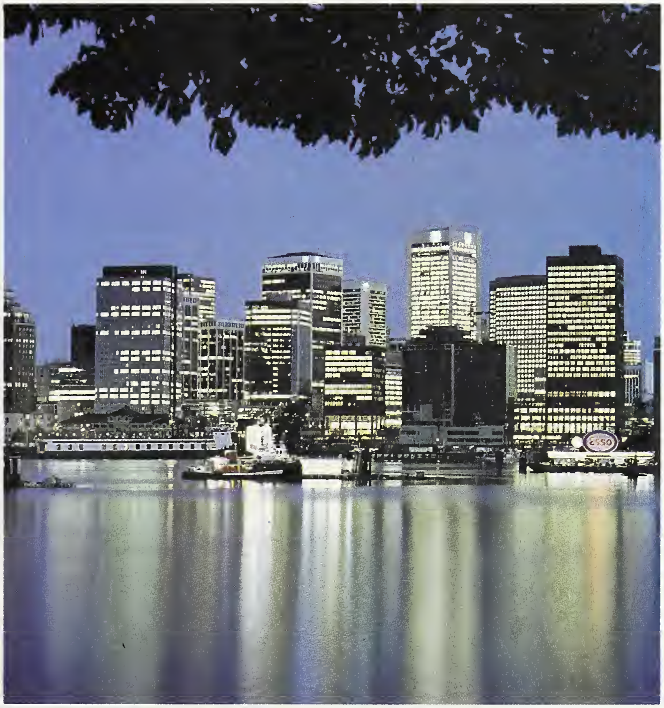
Solar batteries are often used in weather satellites in space. When these satellites are in sunlight, small crystals in the batteries absorb light energy. The energy is changed directly into electricity. This electricity can be used to make radio waves. Radio waves then may be used to send weather reports back to the earth. Why do you think solar batteries are used instead of other batteries for such satellites?

A Second Look

1. What is electricity?
2. What are two kinds of energy which can be changed into electrical energy? How are they changed?
3. Where does nuclear energy come from? What are some uses of nuclear energy?
4. What is solar energy? What are some uses of solar energy?

3 Energy in your future

Today, people are using large amounts of energy. Each year the need for energy is becoming greater. More things, such as cars, are being made which need energy to run. There are also many more people using things which need energy. Therefore, more energy must be made to meet people's energy needs in the future.



Energy problems

Many people have been thinking about energy for the future. They have been asking questions such as these: "Will there always be enough energy for everyone? What will be the sources of energy in the future?" How would you answer these questions?

Supply of fossil fuels. The most common sources of energy today are *fossil fuels* [FOS-uhl FYOO-uhlz]. These fuels are the remains of plants and animals which lived millions of years ago. Some important fossil fuels are coal, petroleum, and natural gas.

Coal is used for making electricity. It is also used in many homes and industries as a source of heat energy.

Petroleum is another widely used fossil fuel. It is pumped out of the earth and made into many things. Some of these things are gasoline, oil, fertilizer, pesticide, and plastic. Gasoline and oil are used as fuels to help run many machines. Because petroleum has so

Left: Drilling for oil below the ocean floor. Middle: Mining coal below the surface of the earth. Right: Tapping natural gas from deep under the ground.

many uses, large amounts of it are used every day.

Natural gas is found in the ground near petroleum. This gas is used in many homes and other buildings. It is used for heating and cooking.

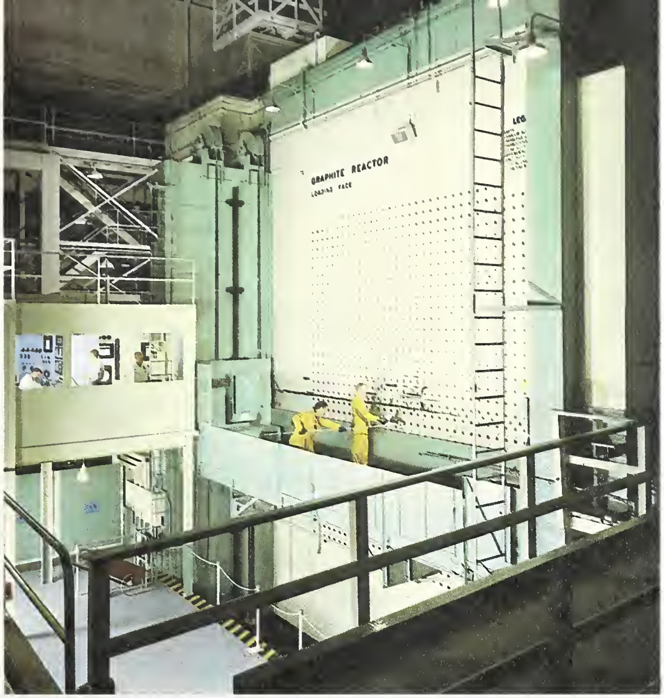
There is, however, a problem with these sources of energy. The supply of fossil fuels is limited. Many people think that someday these fuels will be very hard to find in the earth. Why do you think the supply of fossil fuels is limited?

For You to Think About

Fossil fuels are said to be a form of stored solar energy. Why do you think this is so?

Environmental pollution. When fossil fuels, such as coal and gasoline, are burned, smoke and gases are given off into the air. These things cause the air to become *polluted*. Polluted air can be harmful for people to breathe. Why do you think this is so?

Nuclear reactors need large amounts of water to change nuclear energy into electrical energy. So most nuclear reactors are built near large lakes or rivers. After the water has been heated to make electricity, the water is drained back into the lake or river. If the water is too hot, a kind of pollution, called *thermal pollution,* may come about. In what ways might this heated water be harmful to water plants and animals?



Many improvements have been made in nuclear reactors since this early reactor was built. Why do you think this is important?

Cost of energy. Still another problem with energy is cost. Much money is needed to search for and develop new deposits of fossil fuels. Nuclear reactors cost millions of dollars to build. And because elements used for nuclear fuel are rare, they are very expensive. Equipment used to change solar energy into electricity also costs a lot of money. In fact, it costs much more to make electricity from solar energy than from fossil fuels or nuclear fuels.

There is another problem with changing solar energy into electricity. Solar batteries depend on good weather. That is, if the sky is cloudy, little electricity can be made. Also, during the winter months, the hours of sunlight are shorter than those during the summer. Storing electricity for use on cloudy days or at night is costly.

Solving energy problems

As you have read, supplying energy for people has brought about problems. But people are finding ways to solve these problems.

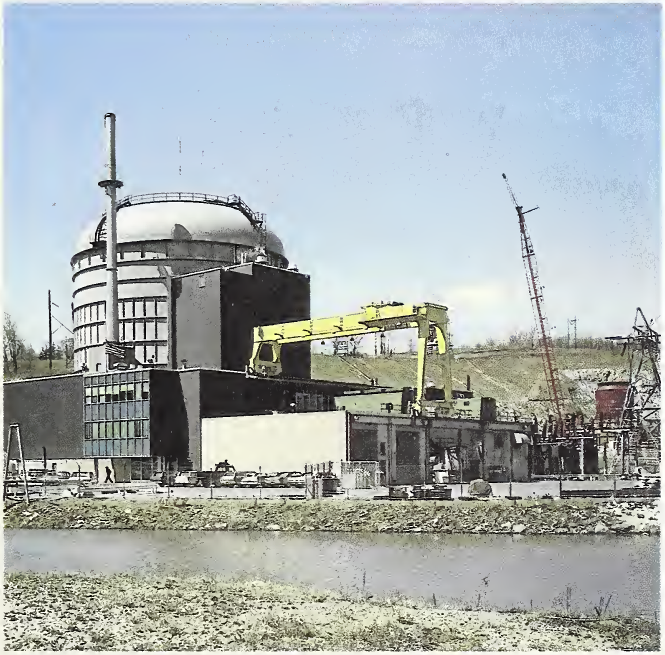
Finding more fossil fuels. People have been mining fossil fuels from the earth for almost 800 years. To keep up with the demand for fossil fuels, people must keep looking for new places to get these fuels from the earth.

Drilling for fuels below the ocean floor off the coasts of some countries has proved to be worthwhile. Large amounts of petroleum have been found in these offshore places. Another new area which is being drilled for oil is the Arctic region. Large amounts of petroleum have been found off the coast of Alaska.

Improving nuclear energy. Finding new areas which have fossil fuels has helped solve energy problems by supplying more fossil fuels. However, the earth's supply of fossil fuels is limited. For this reason, many people are trying to improve other sources of energy. One of these is nuclear energy. Cooling systems have been added to nuclear power plants. These cooling systems can lower the temperature of the used water. The cooled water can be put back into lakes or rivers without harming the water plants and animals.

Another way in which nuclear reactors have been improved is that extra protection against radioactive particles has been built into them. Why do you think this is important?

People worry about the radioactive wastes from nuclear power plants. Why do you think this is so?



Have you seen a nuclear power plant such as this one? If so, where?

Developing solar energy. The high costs of changing solar energy to electricity has kept towns and cities from building large solar batteries. However, people are trying to find a cheaper way of using this energy. People have built solar houses. These houses are built in such a way that they can soak up solar energy and store it as heat energy. This heat energy can then be used to heat these houses and to generate electricity. In this way, the cost of heating and lighting these houses could be less than that of electricity from a power company.

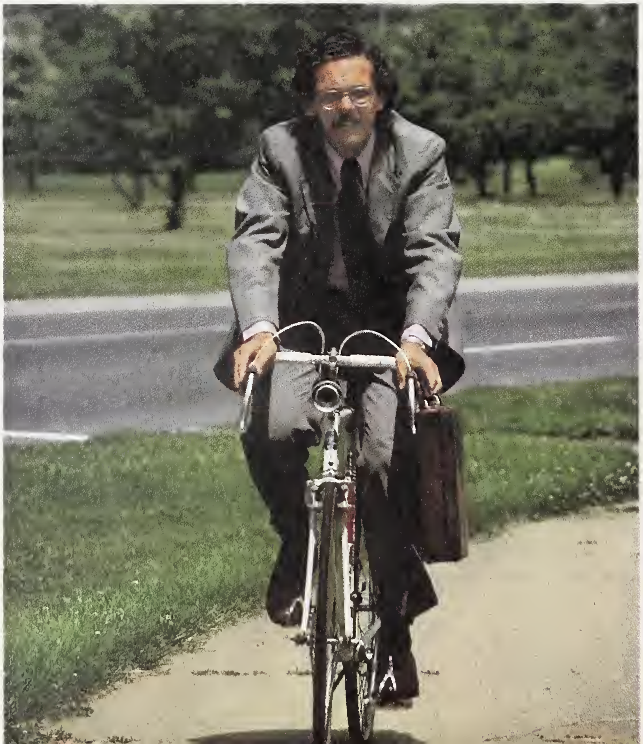
Using heat from the earth. Still another source of energy is the natural heat in the earth. In many places around the earth, large amounts of heat come up from deep underground. Such places are volcanoes, geysers, and hot springs.

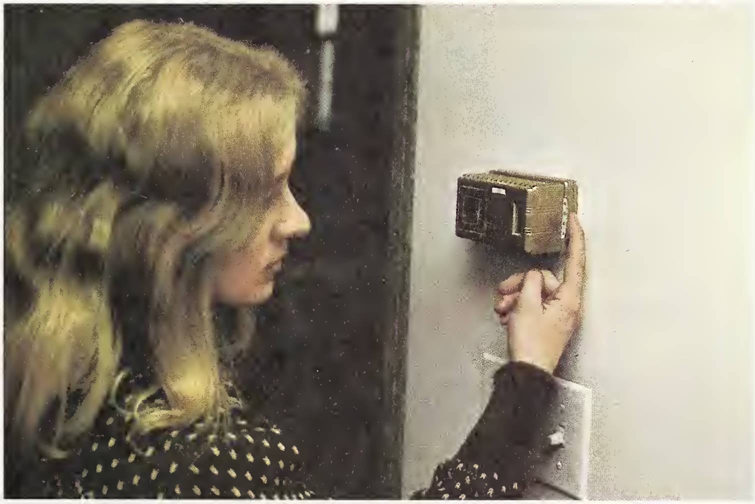
For many years, volcanoes and geysers were either a problem or an area of sight-seeing interest. Today, steam from geysers is being used to make electricity. Hot lava from volcanoes can be used to heat water to make steam. This steam can then be used to make electricity.

Above: Natural heat from the earth forces steam out of a geyser. Below: A geothermal power station uses heat from the earth to make steam. The force of the steam is then used to make electricity.

Conserving energy. People have realized that some energy problems can be helped by *conserving*, or using less, energy. Therefore, some people are using less energy than they have been used to using. Many people have learned to conserve electricity. How might this help solve energy problems? In what ways might you conserve electricity?

Many schools and businesses have used less heating in the winter and less cooling in the summer. People are learning to use their cars less often. Many provinces have lowered the speed limits on highways. How might these things help solve energy problems? How are the people pictured on this page and the next helping to solve energy problems?





A Second Look

1. What are some problems with energy?
2. What are some things people are doing to help solve energy problems?

Workers Who Use Science

Since the discovery of radiant energy from radioactive elements, many people have been involved in the uses of this kind of energy.

Some of the people who work with radiant energy are called *X-ray technicians* [tehk-NIHSH-uhnz]. These people use X rays and other radioactive materials to find the cause of some diseases and also to treat some diseases.

X-ray technicians take X-ray pictures of bones and other parts inside the body. The pictures are then studied by a doctor to help find parts of a person's body which may not be working the way they should. If a doctor decides that someone, such as a person with cancer, needs X-ray treatment, the X-ray technician gives the treatment.

Many X-ray technicians work in special fields of medicine. Some technicians work in the field of dental care. The use of X rays can help a dentist discover and treat certain problems with a person's teeth or gums. Other technicians work with X rays of broken bones. These X rays can be helpful to doctors when they set the bones for proper healing.

To find out more about the work of X-ray technicians, try to find answers to these questions:

How can X-ray technicians help doctors find and treat diseases of the heart and brain?

Besides X rays, what other kinds of radioactive materials do X-ray technicians use?

Along with sources of your own, writing to the following organization may be helpful to you: The Canadian Society of Radiological Technicians, 280 Metcalfe Street, Suite 410, Ottawa, Ontario K2P 1R7.

Reviewing the Main Ideas

Energy is the ability to cause change.

Some kinds of energy are chemical energy, mechanical energy, sound energy, heat energy, radiant energy, electrical energy, and nuclear energy.

Each kind of energy can be changed into other kinds of energy.

Electrical energy can be made from a generator or a battery.

Nuclear energy comes from the centre of the atom.

The oldest known source of energy is the sun.

People use large amounts of energy every day. Because of this, there are energy problems, such as limited supply of fossil fuels, high cost, and pollution.

People are working to solve energy problems so there will be enough energy for everyone in the future.

Reading About Science

Asimov, Isaac. *How Did We Find Out About Electricity?* Pickering, Ontario: Beaverbooks, 1973.

———*How Did We Find Out About Energy?* Pickering, Ontario: Beaverbooks, 1975.

Jones, Clair, et al. *Pollution: The Dangerous Atom.* Don Mills, Ontario: J.M. Dent and Sons (Canada) Ltd., 1972.

Knight, David C. *Harnessing the Sun: The Story of Solar Energy.* Agincourt, Ontario: Gage Publishing Limited 1976.

Rothman, Milton. *Energy and the Future.* Toronto, Ontario: Grolier Limited, 1975.

Testing for Understanding

Ideas to Check

On your paper write *T* for each sentence that is true and *F* for each sentence that is false.

1. There is chemical energy in the food you eat.
2. Kinetic energy is stored mechanical energy.
3. When matter is rubbed against other matter, mechanical energy is changed to solar energy.
4. Infrared waves are also known as heat waves.
5. Radio waves are a form of radiant energy.
6. Electricity can be made from chemical energy.
7. Nuclear energy comes from the center of the atom.

Words to Use

Write on your paper the word that best fits in each blank below. Choose from these words: *pollution, geyser, prism, vibrate, electricity, solar, kinetic, potential, petroleum.*

1. ____ and ____ are two forms of mechanical energy.
2. ____ is a very useful fossil fuel.
3. Heat from a ____ can be used to make electricity.
4. Green plants change ____ energy to chemical energy when making their food.
5. A ____ can bend a ray of light and break it down into many colours.
6. Mechanical energy can cause matter to ____ and form sound waves.
7. Solar batteries can change sunlight into ____.

Having Fun with Science

A Story Without Words

Sound energy is an important part of people's lives. However, people can communicate without using sounds. Make up a story. Then "tell" your story by actions. How well can others understand what you are telling them? Have others tell you a story without words. How well can you understand them? What kind of energy did you use in telling your story? Explain your answer.

Lights Out

Imagine living for a week with no electricity! What would people do without it? First, make a list of all the things which use electricity. Then tell how people's lives would be changed by not having electricity.

City Planner

Design a city for the future. Make plans for a city that has plenty of energy. What will your city look like? Where will your city be located? What will be your sources of energy? How will you solve energy problems such as waste, pollution, and high costs?

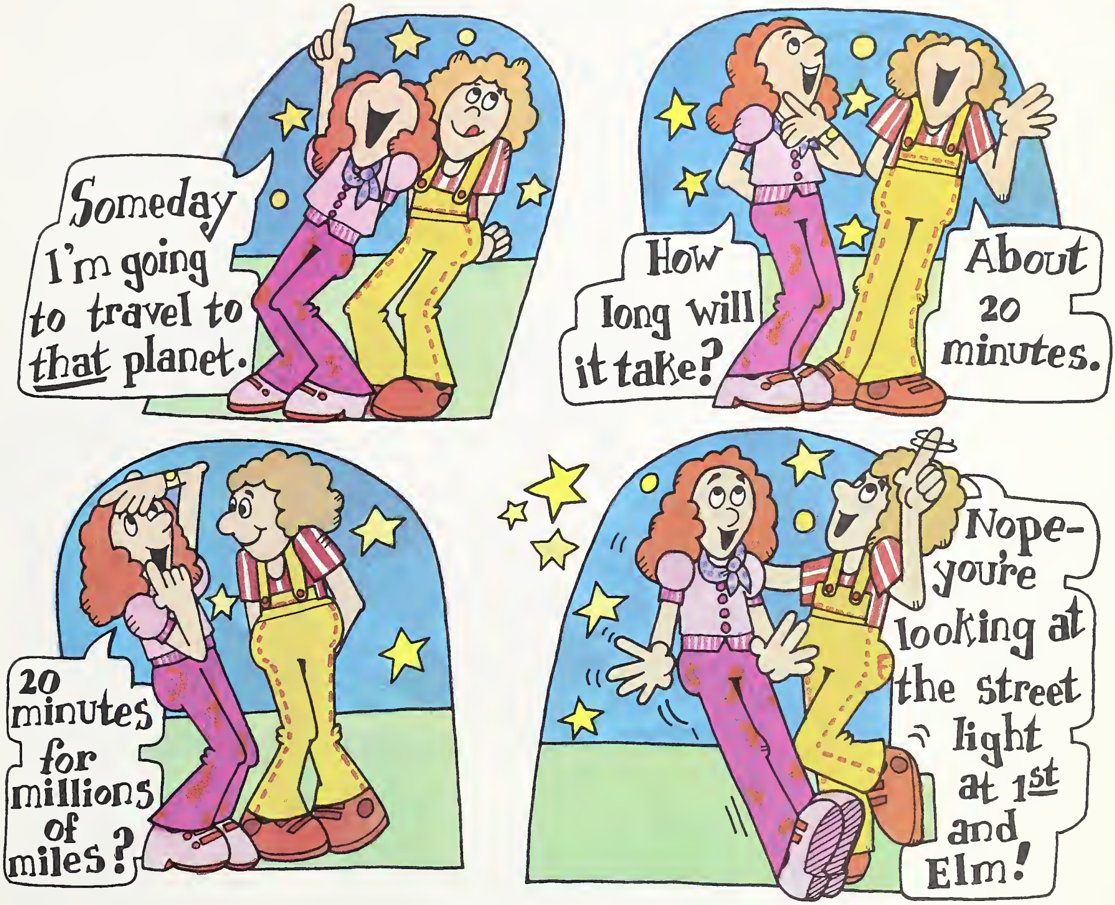
Find the Energy

Name the kinds of energy you can spot in this paragraph.

Jill jumped from the loud, unexpected crash. She hurried to the light switch and turned on her porch light. Out in the street, an ice-cream truck had turned over on its side. She could see ice cream flowing down the street!

5 The Earth in Space

1 Looking out from the earth
2 Some interesting neighbours
3 A special neighbour
4 A closer look at the universe


Someday I'm going to travel to that planet.
How long will it take?
About 20 minutes.
20 minutes for millions of miles?
Nope—you're looking at the street light at 1st and Elm!

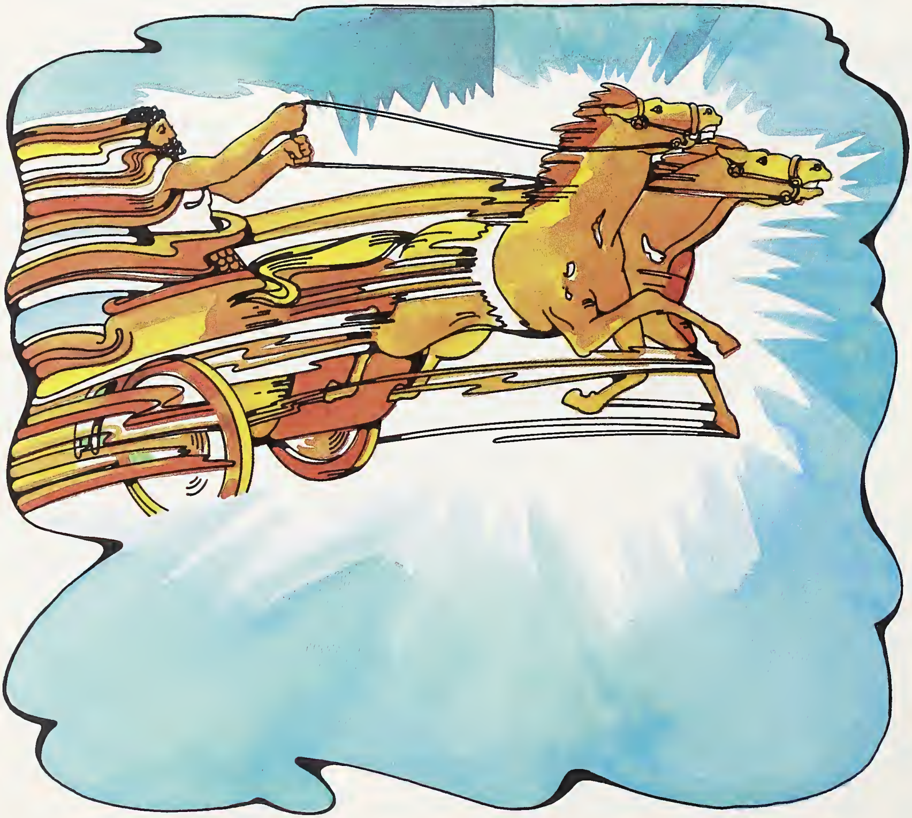
What are some of the things you can see as you look into space from the earth?

How are some of these things important to the earth?

1 Looking out from the earth

Suppose for a moment you had lived in Egypt in the year 150 B.C. You would have been told that the earth was the centre of the universe. And you would have had no reason to doubt this. Each day, a sun god Re sailed a flaming boat across the sky.

However, if you had lived in Greece, you would have been told that the Egyptians were wrong. There was no Re or sailboat in the sky. Instead, a sun god Helios drove a chariot across the sky!



For many years, people believed these kinds of ideas about the sun. Although the gods and their transportation changed, people believed that the sun moved around the earth. It was not until the fifteenth century that Nicolaus Copernicus [koh-PUR-nih-kuhs], a Polish astronomer, suggested that the sun, not the earth, is the centre of the universe.

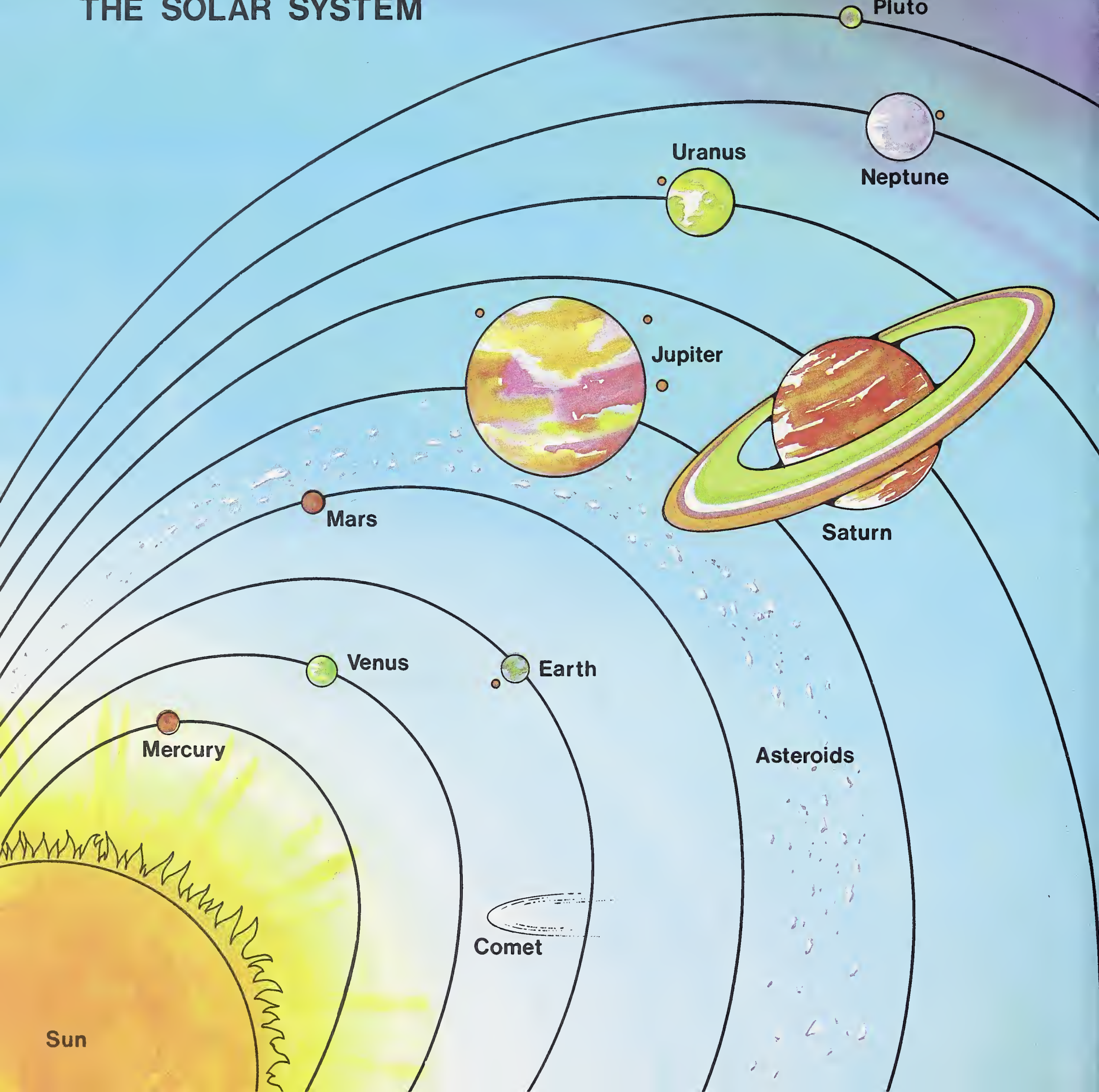
It was hard for people to believe that the earth moves around the sun. In the sixteenth century, however, a German astronomer, Johannes Kepler, continued with the Copernican idea. Kepler was able to plot the movements of the earth and other planets around the sun. Because of this, he was able to prove that the earth-centred belief was wrong. Why do you think it was easy for people to believe that the sun moved around the earth?

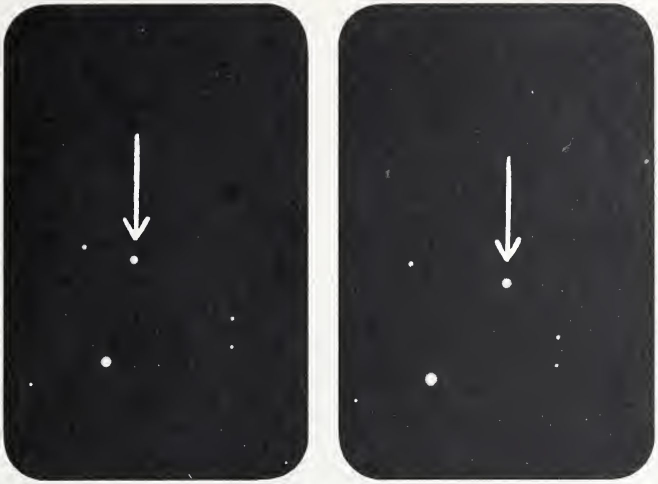
Today the universe is known to be much larger than ever believed by the ancient sky watchers. The *solar system* in which the earth belongs is just a part of a vast universe. The solar system, as it is known today, is made up of the sun and the things which *orbit,* or go around, the sun. These things include the *planets, moons, asteroids, comets,* and *meteors.*

The planets

Although ancient people misunderstood the movements of the earth and the sun, they did know many things about the solar system that are still true today. One important thing they knew was how stars and planets differ. This helped people study the solar system. Why might people even today confuse stars and planets?

THE SOLAR SYSTEM



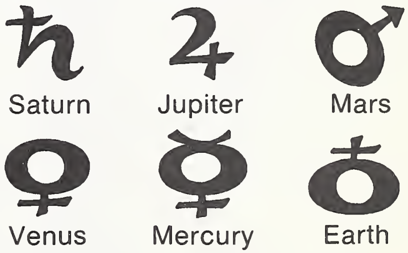


These two photographs were taken several nights apart. By comparing the two, you can distinguish Pluto from the stars in the background.

The word planet comes from a Greek word which means wanderer. This word was used because planets appear to wander away from the stars in their background. Stars seem to be fixed in their position in the sky. These "wandering stars" were the planets that are known today.

Without using a telescope, you can see five planets at different times of the year. These planets are believed to have been recognized thousands of years ago. Early writings refer to these planets in the form of symbols. Which planets have you seen?

SYMBOLS OF PLANETS



Size of the planets. As you may know, planets differ in size. Most of the smaller planets are close to the sun. This is generally true, except for the planet Pluto. Pluto is the farthest planet from the sun, but it is smaller than the earth. Because of Pluto's small size, some people believe that it was a moon of the planet Neptune billions of years ago.

FINDING OUT

How can you compare the size of the planets?

You will need: paper, pencil, scissors, ruler

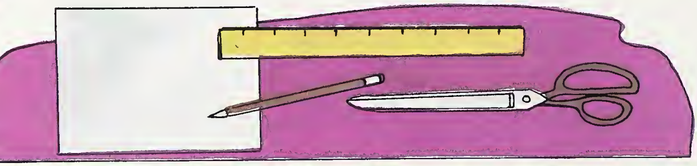
To scale down the size of the planets, you can use any unit of measurement. The smallest unit can be the smallest planet. You might use 1 cm as 1 unit.

- Mark off 1 unit on a piece of paper. This represents the diameter of Mercury. Make a circle from this diameter as shown.
- Use the chart below to measure the diameter of each planet.
- Cut out and label each planet.

Which planet is the largest?
Which planet is the second largest?
Which planets are about the same size as the earth?
How might you compare the size of the sun with the size of each of the planets? Try it.

Units for Diameters

Venus 2½
Earth 2⅗
Mars 2⅖
Jupiter 29
Saturn 25
Uranus 10
Neptune 9
Pluto 1
Sun 287



Moving in space. You may not feel the earth's motion or see other planets in motion. But all nine planets in the solar system are always moving in their orbit, or path, around the sun. One trip around the sun is called a *revolution* [REHV-uh-LOO-shuhn]. One revolution is a planet's year.

Revolution Time of the Planets

According to Earth Revolution Time of 1 Year

Mercury	Venus	Mars	Jupiter
88 days	227 days	1.88 years	11.9 years
Saturn	Uranus	Neptune	Pluto
29.5 years	84 years	164.8 years	248 years

The planets' orbits are not exactly round. They have an *elliptical* [ih-LIHP-tih-kuhl], or slightly oval, orbit. For this reason, a planet's distance from the sun changes throughout its year. The earth, for instance, is within 148 000 000 km of the sun at its closest point. It is over 151 000 000 km away from the sun at its farthest point. What might happen to the earth if it were to move closer to or farther from the sun that it does?

Mercury has a greater change in its elliptical orbit than the earth has. Mercury varies over 25 000 000 km in its distance from the sun. Pluto shows the greatest change. At one time during Pluto's year, it moves closer to the sun than Neptune!

FINDING OUT

How can you compare the planets' distance from the sun?

You will need: shelf paper (or other long paper), pencil, ruler

To scale down the distance of planets from the sun, you can use any unit of measurement. The smallest unit can be the distance of the closest planet to the sun. You might use 1 cm as 1 unit.

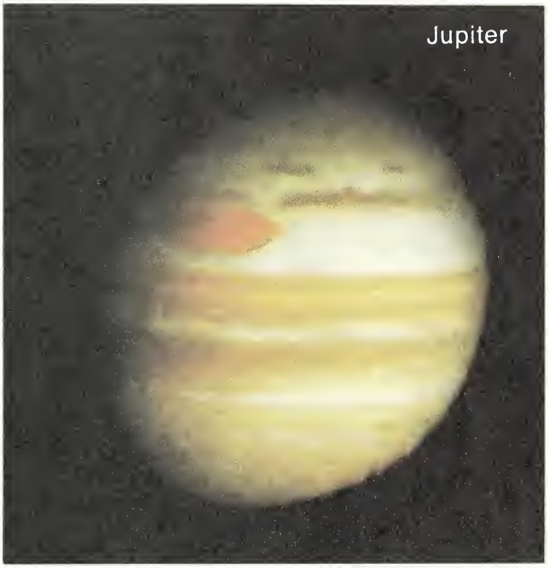
- At one end of your paper, mark a spot to represent the sun.
- Measure 1 unit from the sun. This represents the distance of the orbit of Mercury from the sun.
- Use the chart below to measure the distance of each planet from the sun.

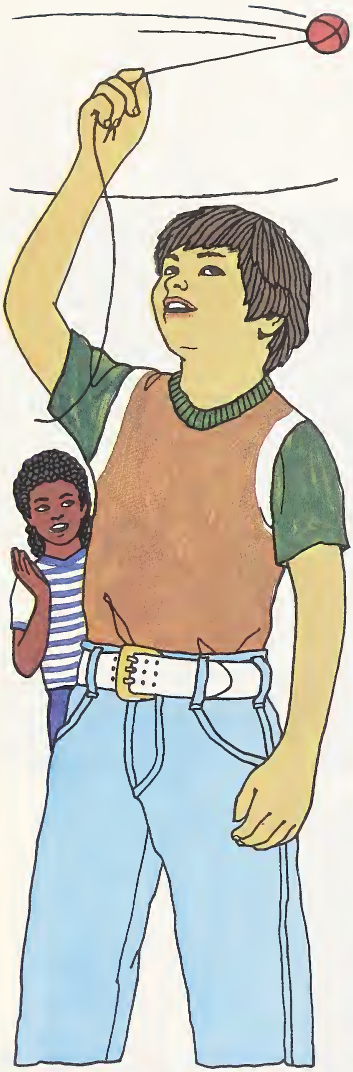
Which planets are about the same distance apart in the solar system?
Which planets orbit near other planets?
Which two neighbouring planets have the greatest distance between them?

Units for Distances from the Sun

Venus	1⅘	Jupiter	13	Neptune	77
Earth	2⅗	Saturn	24	Pluto	102
Mars	4	Uranus	46		

Each planet orbits the sun at a different speed. The planets which are closer to the sun move faster than those which are farther away. This is because the sun's gravity pulls more strongly on the planets closer to the sun. Planets which are closer to the sun must therefore orbit faster to keep from being pulled toward the sun.





FINDING OUT

How can you show how the sun's gravity affects the orbiting speed of a planet?

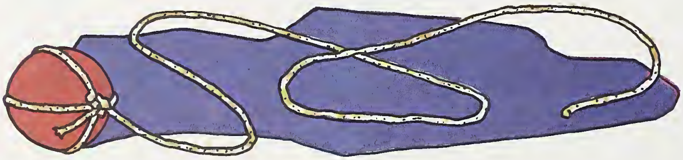
You will need: small rubber ball, string

- Attach the string to the rubber ball. The ball represents a planet. The string represents the pull of gravity. (The shorter the string, the stronger the "gravity.")
- Hold the string about 30 cm from the "planet." Orbit the "planet" around you as shown.
- Now hold the string about 60 cm from the "planet." Orbit the "planet."

Which time did you have to move faster to keep your "planet" in orbit? Why?

- Now hold the string about 90 cm from the "planet." Orbit the "planet."

How did the speed of this orbit compare to the other two? Why?
What might happen if the orbiting "planet" were to lose its pull of "gravity"? Why? Try finding out.



Mercury

As you may know, the earth takes 365.25 days to orbit the sun. It travels almost 30 km each second! Mercury, the planet closest to the sun, travels 48 km each second. Why do you think you don't feel the fast moving speed of the earth?

Besides moving around the sun, each planet moves in another way. It *rotates,* or spins around in place, like a top. Each planet rotates around an imaginary line through the planet, called its *axis.* One rotation is the planet's day. The earth makes a complete rotation on its axis about once every 24 hours. What changes does this rotating cause on the earth?

For You to Think About

Every fourth year on the earth is known as leap year. This year adds one extra day to the calendar. Why do you think this day is added?

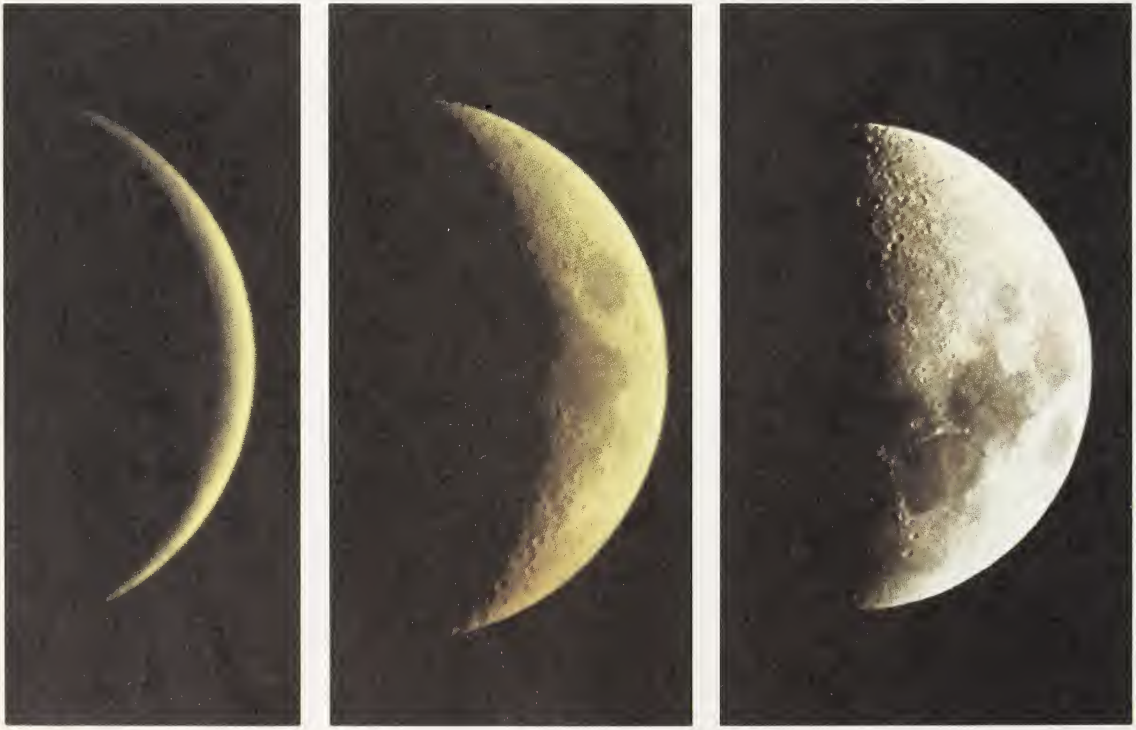
Rotation Time of the Planets
According to Earth Rotation Time of 23 Hours, 56 Minutes

Jupiter 9 hours 50 minutes	Saturn 10 hours 14 minutes	Uranus 12 hours 20 minutes	Neptune 15 hours 48 minutes
Mars 24 hours 37 minutes	Pluto 6 days 9 hours	Mercury 59 days	Venus 225 days

Moons

Besides the sun, probably the most familiar sight to you from the earth is its moon. The moon is about 386 000 km from the earth and is the only natural object which orbits the earth.

A month on the earth. One of the reasons why ancient sky watchers believed that the earth was the centre of the solar system was that they clearly saw that the moon moves around the earth. However, the discovery that other moons orbit their planets was further proof that the earth is not the centre of the solar system.



The moon's complete orbit from full moon to full moon is 29 days, 12 hours, and 44 minutes. It is this time that is used to help set up a calendar month on the earth. How does this time compare to each of the 12 months on a calendar?

During the time of one month on the earth, the moon causes noticeable changes on the earth. One change is the motion of ocean water. The moon's gravity pulls on the oceans' water and causes high and low tides. The depth of ocean water changes on opposite sides of the earth twice each day. How might this affect plant or animal life in the oceans?

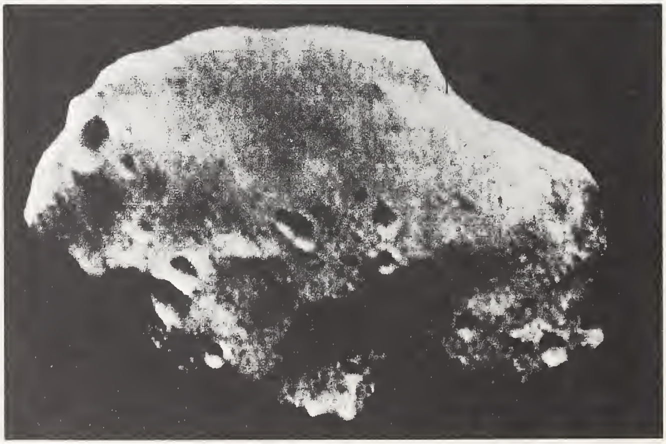
Other planets' moons. Not all planets have one moon, as the earth has. While Mercury and Venus have no moons, Mars has two moons. These moons are named Phobos and Deimos after the two horses which the ancient people believed drew the chariot of the ancient god Mars.

Phobos and Deimos are unlike the earth's moon in that they are described as oddly shaped lumps of rock. Phobos, the larger of the two, measures only 14 km long and 10 km wide.

Jupiter has the most moons of any planet. It has thirteen. Saturn has ten, and Uranus has five. If Pluto has any moons, they have not been discovered. Little is known about Pluto because of its great distance from the earth. However, many people believe that Pluto has no moons.

Some of the moons of Jupiter, Saturn, and Uranus orbit their planet the "wrong way." While the planets, asteroids, comets, meteors, and most moons orbit in a

Phobos



This model shows Jupiter and some of its moons. How do you think these moons may have been discovered?

counterclockwise motion, these moons travel in a clockwise orbit. Of Neptune's two moons, one travels counterclockwise and the other travels clockwise.

One moon of Saturn, Japetus, becomes six times brighter on one side of its orbit than on the other side. However, no one is quite sure why Japetus has its bright side or why any moons orbit the wrong way.

Many people believe that if they knew exactly how the solar system was formed, they would better understand the motion of planets and moons. Why do you think this could be true?

A Second Look

1. What were some ancient ideas about the solar system?
2. What are rotation and revolution of the planets?
3. What effect does rotation and revolution have on the planets?

2 Some interesting neighbours

Most planets and moons have followed their same predictable orbits for millions of years. However, other objects appear and surprise sky watchers every year!

Asteroids

There is a large gap between the orbit of Mars and that of Jupiter. Many people had thought that a planet would be discovered in this gap. Instead of a planet, many small, rocky particles were discovered. These rocky particles are called *asteroids* [AS-tuh-ROYDZ], from the Greek word which means resembling a star. The entire area of these orbiting asteroids is called the *asteroid belt*.

In 1801, the first asteroid, Ceres, was identified through a telescope. Ceres is the largest asteroid. It measures 725 km in diameter. How does the size of Ceres compare with the size of the earth?

About 2000 asteroids have been identified. Some people suspect that there may be 10 000 asteroids in this belt. The number of asteroids would be difficult to count. Why do you think this is so?

History of "the belt." No one is sure exactly how the asteroids became a part of the solar system. However, many people agree with one of three different ideas. Some people believe that at one time there was a planet orbiting the sun in the asteroid belt area. For some reason, the planet was broken apart, and its small pieces continue to orbit the sun. Some suggest that the pull of Jupiter's gravity caused it to break apart.

Other people believe that when the solar system was first forming, these particles were joining to become a planet. For some unknown reason, these particles never joined, and the rocky pieces remained separated.

Asteroids

Still other people think that there may have been two or more small planets in this orbit. The gravity of each planet pulled them toward each other. This caused the planets to collide. On impact, they broke up into small pieces.

Some special asteroids. While most asteroids orbit the sun between Mars and Jupiter, some others have very uncommon orbits. And because asteroids are so small, their orbit is often changed by the gravity of nearby planets.

The asteroid Icarus has an orbit which ranges from outside the orbit of Mars to inside the orbit of Mercury. Icarus came within 7 000 000 km of the earth in 1968. It is expected to come close to the earth again in 1987. The gravity of another planet, however, may cause the orbit of Icarus to change completely.

The fact that the orbit of an asteroid may change was proved by the asteroid Hermes. Hermes' orbit ranged from outside the orbit of Mars to inside that of Venus. In 1937 this asteroid came within 800 000 km of the earth. Since that time, however, the orbit of Hermes has changed. In fact, Hermes has never been seen again.

One asteroid can be seen from the earth without the use of a telescope. This asteroid, named Vesta, is only about 400 km in diameter. Vesta is not the largest asteroid nor is it closest to the earth. It can be seen because it reflects more light than any other asteroid. This is because Vesta has a very smooth surface. Why do you think a surface which is smooth can reflect more light than a surface which is rough?

FINDING OUT

How can you show that a smooth surface reflects more light than a rough surface?

You will need: modeling clay, flashlight

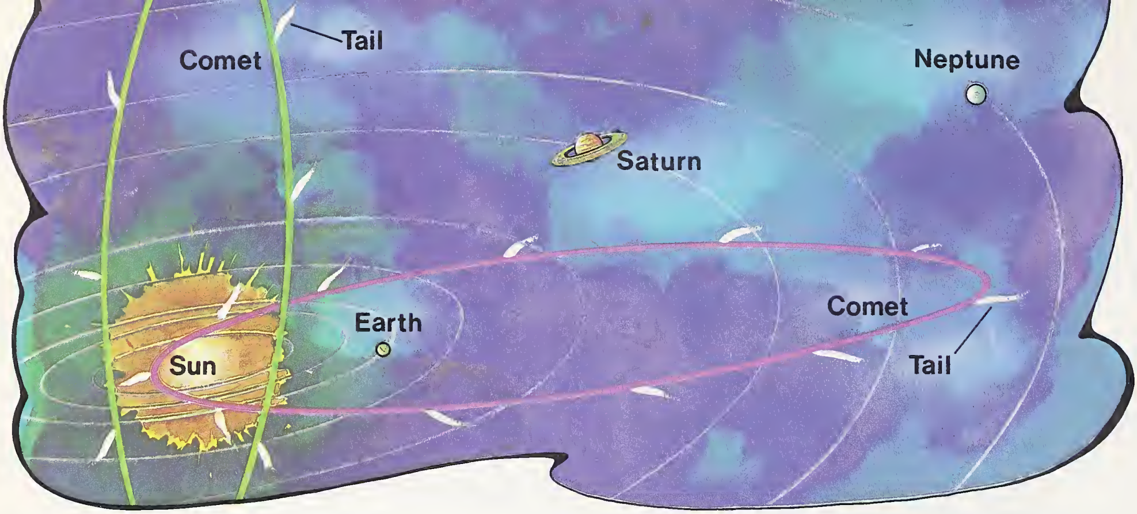
- Divide the clay into 3 or more "asteroids."
- Make one "asteroid" very smooth. You might add water to help you do this.
- Make another "asteroid" uneven with your fingers or knuckles.
- Make still another "asteroid" very rough. You might use a pencil point for making deep holes.
- Shine the light on each "asteroid."

Which "asteroid" reflected the most light back to you? Why?
Would the size of the "asteroid" change the amount of light being reflected? If so, how?

The trojan asteroids. There are other asteroids separated from the asteroid belt. These asteroids are in the orbit of Jupiter and are called the *trojan asteroids.*

There are two groups of trojan asteroids. One group travels in front of Jupiter along its orbit. The other travels behind Jupiter along its orbit. Both groups stay the same distance from Jupiter.

No one is quite sure why these asteroids travel in Jupiter's orbit. No other planet is known to have asteroids that travel with it.



Comets

The early Greek sky watchers discovered other orbiting objects in the solar system. These objects were called *cometes asters,* or “hairy stars,” because of their fuzzy appearance. These objects have come to be known as *comets* [KOM-uhts].

The orbits of comets are somewhat like those of planets and asteroids. That is, comets also have elliptical orbits. The diagram on this page shows the orbits of some comets. How is the elliptical orbit of each comet different from the elliptical orbit of the earth and other planets?

Because of the shape of its orbit, a comet may not be seen very often. One comet may orbit the sun every three or four years. Another comet may take hundreds or even thousands of years to orbit the sun.

Some people believe that still other comets pass by the sun, go off into space, and never return. Do you think these comets could be part of the solar system? Why or why not?

Heads or tails! Comets are believed to be made up of partly frozen hydrogen, helium, and neon. As comets travel through space, they pick up tiny bits of dust. This dust, about the size of grains of sand, sticks to the frozen mass. For this reason, comets are often described as large, dirty snowballs!

The frozen mass of particles is known as the head of the comet. The head of a comet may be very small. It may be so small that it cannot be seen from the earth. The heads of other comets are large enough to be seen from the earth.

When most comets travel near the sun, they form what is called a tail. The tail extends from the head. It is the tail which makes comets different from each other. Some people believe that no two comets are alike.

The tails of most comets appear as smokelike streamers. Tails may be either curved or straight, short or long. Some of the longest tails may be 161 000 000 km long. However, some comets have no tails at all. And some comets have two tails.

How are the tails of these two comets different?

Halley's Comet

The tail of a comet always faces away from the sun. As the comet travels toward the sun, the tail is behind its head. After the comet goes around the sun and travels back in its orbit, the tail is in front of its head!

Comets lose some of their mass on each orbit. The sun causes some of the frozen particles to melt and break off. Each orbit causes a comet to become smaller and smaller. At some time a comet will lose practically all its mass.

A famous comet. Probably the most famous comet is Halley's comet. This comet is named after the British astronomer Edmund Halley. In 1682, Halley carefully watched the path of this large comet. By doing this, he was able to figure out the exact size and shape of its orbit. Halley also read many old books about comets. He was able to show that this same comet had probably appeared in 1066, 1456, 1531, and 1607.

For You to Think About

If you were to look at a picture of a comet, would you know in which direction the comet was traveling? Why or why not?

Halley then predicted that this same comet would return about every 76 years. This meant that the comet would appear in the years 1759, 1835, and 1910. His predictions were correct. Halley's comet did appear in those years. It is expected to return to the sun once again in 1986. Do you know of any other famous comets? If so, which ones?

Meteors

Although asteroids and comets are not seen often, there are other bright moving objects which can be seen on almost any clear night. These objects are often called shooting stars because they look like tiny stars which streak across the sky.

These shooting stars are small metal or rocky objects called *meteors* [MEET-ee-urz]. Meteors pass through the earth's orbit. The earth's gravity then pulls them into the atmosphere and toward the earth.

Shooting Star

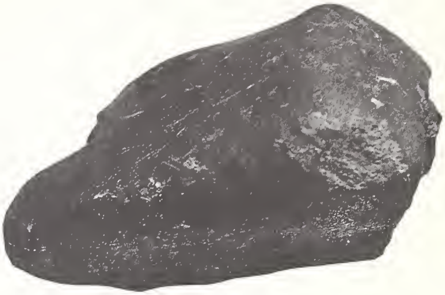
The pull of the earth's gravity causes most meteors to fall from 30 to 50 km each second. This great speed causes friction between the meteor and the atmosphere. The friction causes the meteor to glow brilliantly from heat. Some meteors are believed to have a temperature of about 2204° C.

Meteors first appear about 100 km above the earth. The extreme heat causes most meteors to burn out and disappear about 80 km above the earth. Some large meteors, however, may not burn out until they are about 50 km above the earth.

This crater, near Winslow, Arizona, was made by the largest known meteorite. It is believed to have landed over 50 000 years ago.

Meteor visitors. Not all meteors disappear before they reach the earth. Some meteors are so large that the heat does not cause them to burn up completely. Meteors which land on the earth are called *meteorites* [MEET-ee-uh-RYTS].

Because of their large size, most meteorites are believed to be from the asteroid belt. The picture on this page shows a meteorite which has been found on the earth.



Meteor showers. Many people believe that meteors and comets are related. When the earth moves through an area in which a comet has recently passed, the number of meteors becomes greater. At such times, thousands of meteors can be seen "showering" the sky.

Meteor showers may take place every year. But for some unknown reason, about every 33 years meteor showers are greater. The most famous meteor shower was in 1833. The continuous streaks of light were so great that many people thought that the earth was coming to an end! The next of these showers is expected in 1999.

A Second Look

1. What are asteroids? Where are they found?
2. What are comets? What makes comets different from each other?
3. What are meteors? Meteorites? Meteor showers?

3 A special neighbour

Although people have long known that the earth revolves around the sun, most people speak of the sun as they see it from the earth:

"The sun rises in the east."

"The sun moves overhead and shines a brilliant yellow."

"If it's cloudy, the sun doesn't shine."

"The sun turns red and sets in the west."

But do you think the sun does any of these things?

Some questions about the sun

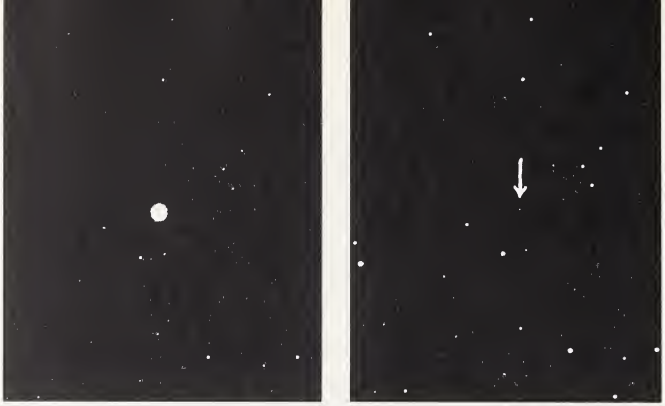
No matter what people say of the sun's changes, most people agree that the sun is very important to living things on the earth. In what ways is the sun important to plants and animals on the earth? In what ways is the sun important to you?

Why does the sun shine? The sun, which is really a star, is made up of about every element known on the earth. But the most common elements on the sun are the gases hydrogen and helium. The large mass of the sun causes the sun to be extremely heavy. The heavy weight of the sun causes great pressure in the centre of the sun. This pressure then causes the hydrogen and helium to react in violent explosions. The explosions allow enormous amounts of energy to be released. These explosions, which take place in the centre of the sun, cause the centre to be more than 15 000 000° C.

The energy from the centre of the sun works its way to the surface. The sun's surface then radiates light and heat energy in all directions. However, only a small portion of this energy reaches the earth. What do you suppose happens to the rest of the sun's energy?

How long will the sun last? The explosions of hydrogen and helium have been taking place in the sun for billions of years. Some people, however, wanted to know how long these explosions will continue to take place.

Because the universe is filled with average stars like the sun, people have been able to figure out the possible history of an average star. When an average star is about 10 billion years old, its centre begins to shrink. This



Which stages of this star do you think are shown in these pictures?

causes the centre of the star to become hotter. When this happens, more energy is given off. The increase in energy makes the outer area larger. This stage of a star is known as the *red giant* stage.

Because of the huge size of a star at the red giant stage, it then uses up its energy. The whole star then begins to shrink. This shrinking stage of a star is called the *white dwarf* stage. A star stays as a white dwarf for several billion years. All activity slowly comes to a stop. A star is then called a *black dwarf.*

Although the sun is believed to be an average star, there is no need to worry. Many people agree that the sun will stay pretty much the same as it is for about 5 billion more years!

For You to Think About

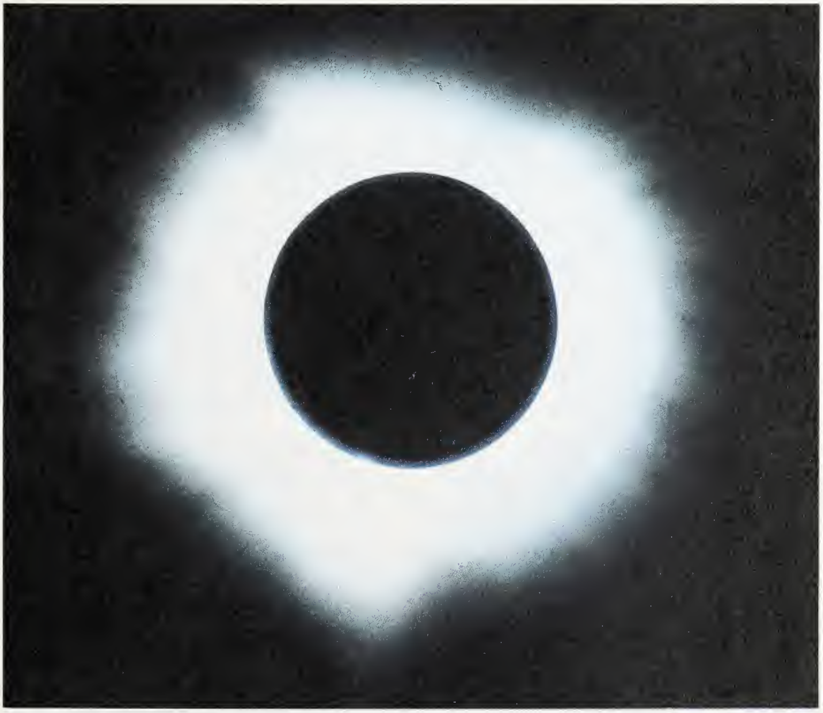
While the sun is very important to all living things on the earth, it is sometimes harmful. In what ways do you think the sun can be harmful?

How the sun affects the earth

As said before, the sun's energy provides light and heat on the earth. This energy helps support living things on the earth. The sun is also important because of the many changes the sun causes on the earth. Most of these changes are caused by different parts or activities of the sun.

The corona. The outer part of the sun is called the *corona* [kuh-ROH-nuh]. The corona extends out about 1 500 000 000 km from the sun. The light and heat on the earth are part of the sun's corona.

The corona, which is best studied during an eclipse of the sun, looks like a halo surrounding the sun. Much of the corona contains layers of radiation from the hydrogen and helium reactions. Since the earth is within this vast corona, many layers of this radiation surround the earth. The ultraviolet rays in the corona may have caused sunburn on your skin.



FINDING OUT

How can you show the effect of eclipses?

You will need: flashlight, globe, model of the moon or small ball, darkened room

An eclipse of an orbiting object takes place when it is darkened by the shadow of another orbiting object.

- Shine the flashlight on the earth.
- Have someone rotate the earth on its axis.
- Have another person slowly orbit the moon around the earth. (The flashlight, the earth, and the moon should be held at the same height.)

What are the positions of the earth and the moon when there is an eclipse of the moon? Where can this eclipse be seen from the earth?
What are the positions of the earth and the moon when there is an eclipse of the sun? Where can this eclipse be seen from the earth?
Where must a person be standing in order to see an eclipse of the earth? Why?

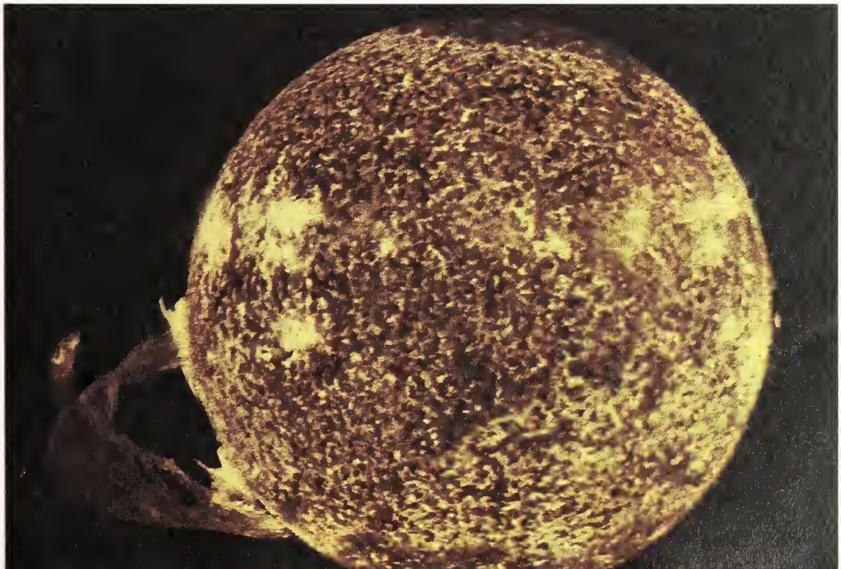
Solar flares. One activity of the sun is a *solar flare*. A solar flare is a short disturbance on the sun's surface. During a flare, some of the gases on the sun's surface build up a large amount of energy. This causes an explosion and a release of much heat and light.

Within a day after a solar flare, many shortwave radios are disrupted. Shortwave radios are often used for communication between ground and airplanes or spacecraft. Radio disruptions from solar flares may cause problems. What problems might these be?

Solar flares can also cause changes in magnetic fields on the earth. The needle of a compass often spins or points in the wrong direction after a solar flare. Why do you think this might be a problem?

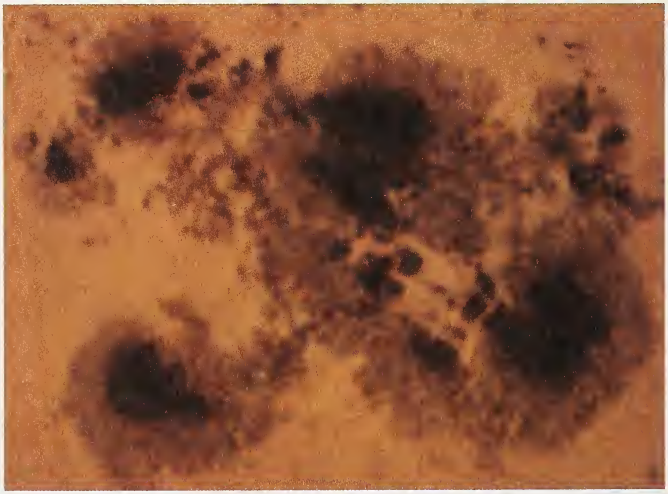
Prominences. Another interesting activity of the sun's surface is a *prominence* [PROM(-uh)-nuhn(t)s]. A prominence is made up of hot layers of hydrogen which are sent out from the sun. These layers may shoot out from the sun at a speed of 725 km/s. Some prominences have traveled about 1 500 000 km from the sun's surface.

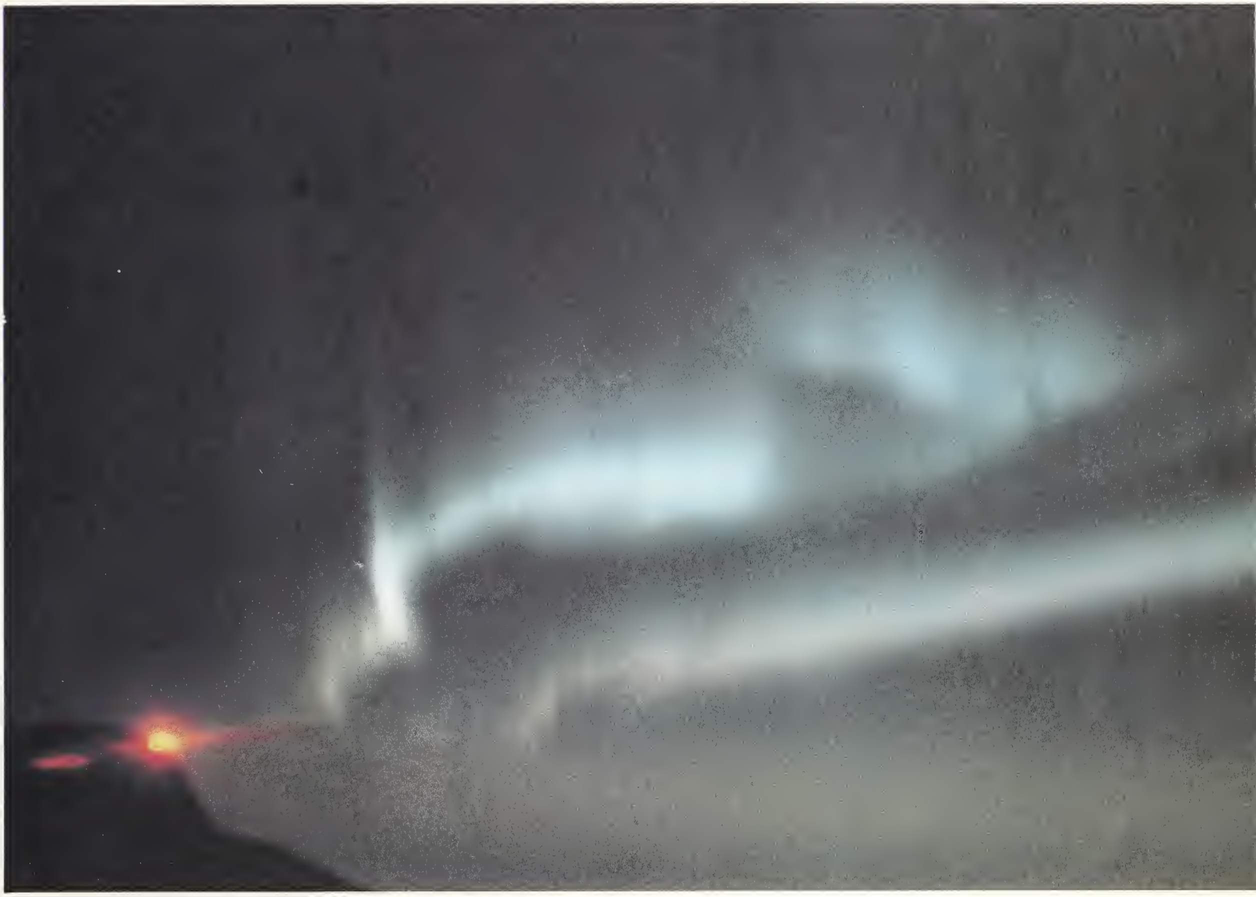
Large prominences strongly affect radio waves. Many times the voices being heard on a radio may become garbled or completely canceled out after a prominence.



Sunspots. Large, dark spots on the surface of the sun have also been studied from the earth. These dark spots are called *sunspots*. Sunspots are cool areas on the sun. They may be 2000 degrees cooler than the rest of the sun's surface. Sunspots may appear on the sun for less than a day. Other spots may remain on the surface of the sun for over a year.

For some unknown reason, every eleven years, sunspots become larger. There are also more sunspots than the usual number. Sunspots often change the harvest time of crops on the earth. Many unusual changes in weather also take place during sunspot activity. Such a change might be an extreme change in temperature in a small area on the earth. Some people have discovered that the number of red blood cells in a person's blood may increase or decrease in number when there are large sunspots! However, no one is quite sure how or why sunspots cause these changes.





Some of the most noticeable changes on the earth during sunspot activity are aurora displays. These displays are often called the northern or southern lights.

The northern lights, as seen in Canada, are formations of beautiful lights in the atmosphere. These lights appear as coloured streamers moving and arching in the sky.

Exploring on Your Own

The sun sometimes appears to be red in the morning. Other times it appears to be red in the evening. Find out why the sun appears to change colour.

Rain or shine? Have you ever made plans and were upset because the weather ruined them? If so, you can blame the bad weather on the sun. All changes in weather come about because of the sun.

Heat from the sun causes water in rivers, lakes, and oceans to evaporate. Much of the evaporated water helps form clouds. Many times clouds bring rain or snow.

Clouds also reflect some of the sunlight back into space. This helps cause an uneven heating of the air around the earth. The warm air rises and is replaced by cool air. This moving air may bring about light breezes or hard, blowing winds.

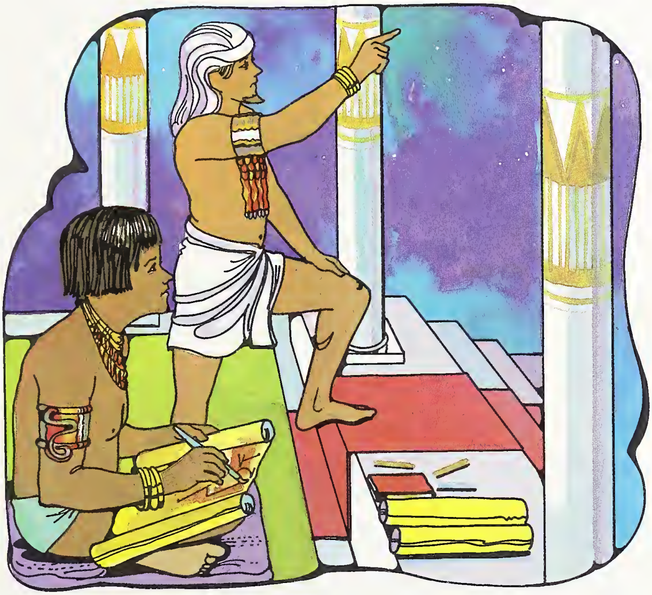
When the earth is heated in some areas more than in others, different air pressures also build up. The different air pressures then start to move around the earth. High pressures move into low pressures. This also causes changes in the weather.

Although the sun causes these same changes every day, tomorrow's weather can be very hard to predict. Why do you think weather predictions are hard to make?

A Second Look

1. What causes the sun to shine?
2. What are the corona, solar flares, prominences, and sunspots?
3. What are some of the ways in which the sun affects the earth?
4. How does the sun affect the earth's weather?

Many of the drawings of the ancient sky watchers are crude or incorrect. But realizing that these people did not have special instruments for viewing, today's sky watchers think their drawings are truly remarkable. Having good, strong eyes was the only advantage some people had for discovering their universe.



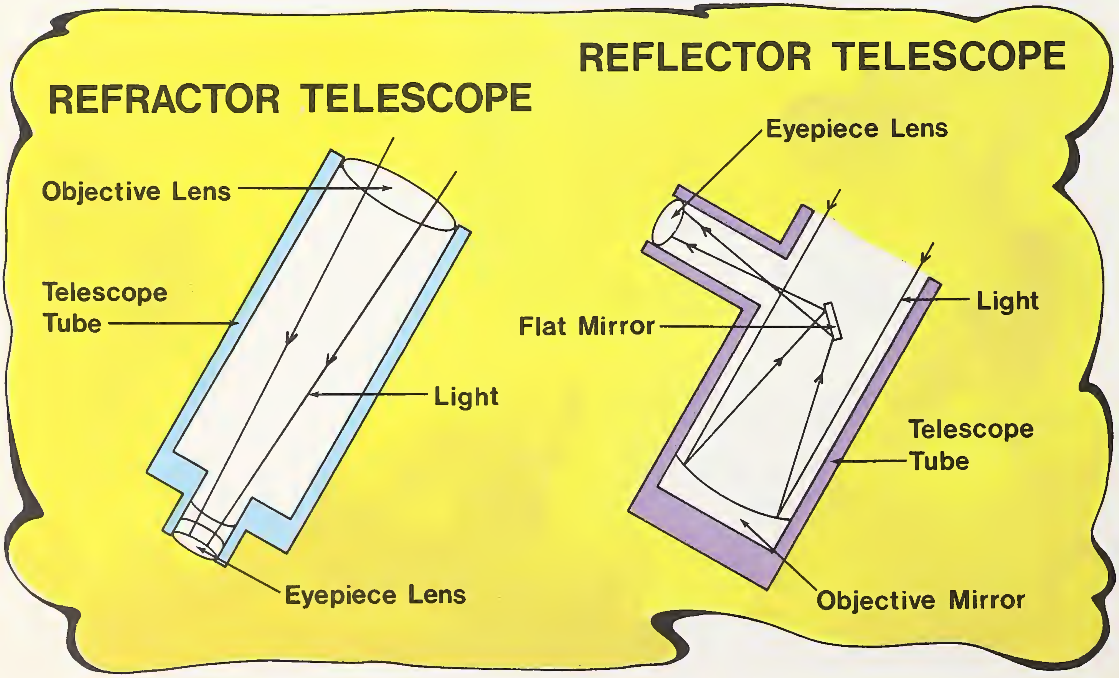
Telescopes

It was not until the early 1600's that the first *telescope* [TEHL-uh-SKOHP] was invented. A telescope does two things. It collects light from a large area and centres it into a small area. A telescope also magnifies, or enlarges, an image. Thus, it makes a distant object, such as a star, look close and clear.

4 A closer look at the universe

Kinds of telescopes. There are two kinds of telescopes. One kind is called a *refractor* [rih-FRAK-tur]. A refractor telescope is made up of a long tube with a glass lens at each end. The *eyepiece* holds the lens through which a person looks. This is where the image is magnified. The *objective* lens, at the other end of the tube, collects the light and centres it into a small area.

The second kind of telescope is called a *reflector* [rih-FLEHK-tur]. It is made up of lenses and a mirror. The image is reflected off a mirror to the eyepiece. The drawing on this page shows how a refractor and a reflector work. In what ways are they alike? In what ways are they different?



Problems with telescopes. After the first telescopes were made, people wanted to see even better images of planets, stars, and moons. Many improvements were made. The glass used for the lenses was highly polished. The lenses were made larger. The tubes were made larger. The mirrors were almost flawless. That is, there were practically no scratches or dust to make the images fuzzy.

One of the largest and best telescopes in the world today has an objective lens that is over 100 cm wide. Its length is almost 20 m! However, there is a point at which a larger telescope does not improve an image. In fact, using a larger telescope can cause problems. Besides light from the stars and planets being magnified, unwanted images are also magnified. The air is filled with dust, smoke, water droplets, and plant spores. These things become magnified and interfere with the images being studied.

This telescope helps people not only see, but also photograph, stars and planets. Why do you think this is important?

For You to Think About

Most large telescopes are set on mountains away from large cities. Why do you think this is so?

Another problem is that the air around the earth moves in layers. This moving air causes light to bend. This causes an image from a distant star or planet to be bent and distorted. A large telescope magnifies the distorted light. This can cause the image of a star or planet to change its size and shape.

Because of these problems, some nights are better than others for using large telescopes. What kind of night do you think would be good for studying the stars and planets?

Solving some of the problems. Because of the dirty moving air around the earth, people thought of moving the telescopes. One of the first ideas was to put a telescope and camera on a large balloon. These kinds of balloons rose about 30 km above the earth. The camera took clear pictures through the telescope. The film was then dropped to the earth by parachute.

This idea did not work for long. During the day, the sun's heat caused the balloons to expand. Some balloons burst. In the evening after the sun set, the balloons began to shrink and to drop back to the earth.

Today, many images are sent back to the earth from telescopes in orbiting spacecraft. Radio waves sent from the earth focus and control the telescopes. The image is then sent by a television signal back to the earth. The pictures are clear of the distorted, smoky light in the earth's air.

Many people would like to set up telescopes on the moon. Images could be sent by television signals back to the earth. Do you think the moon would be a good place for a telescope? Why or why not?

Space exploration and travel

The first space rocket sent into space was in 1957. This rocket held the first *satellite* [SAT-uhl-YT], or orbiting spacecraft, *Sputnik I*. *Sputnik I* orbited the earth and sent radio signals back to the earth.

Satellites and space probes. Since 1957, several hundred rockets have sent satellites into space. Some satellites are equipped with cameras. These cameras take pictures of not only stars and planets, but also of the earth. The pictures are then sent by television signals back to the earth. Why do you think people would want pictures of the earth taken from outer space?

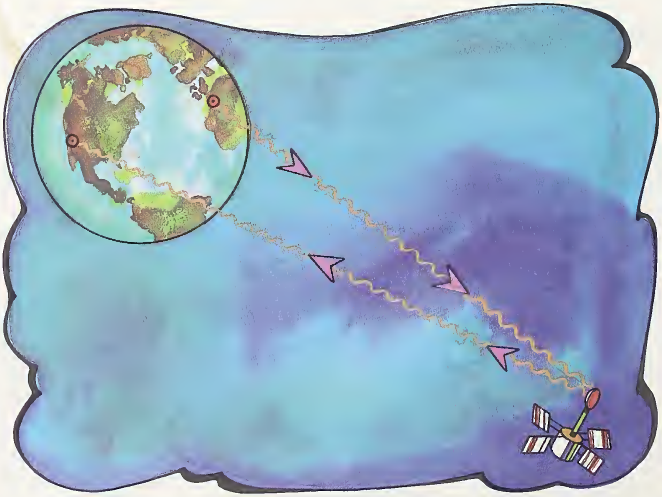
Some other satellites have weather-tracking equipment. These weather satellites keep track of cloud formations and high and low air pressure zones around the earth. This weather information is radioed back to the earth. People have learned much about extreme weather conditions, such as hurricanes, from pictures taken above the earth. In what other ways do you think weather information from these satellites is important?

Still other kinds of satellites are used for communication. These satellites can help people communicate by radio and television around the earth. Have you ever seen a live television broadcast from Europe or Asia? If so, the television broadcast was probably sent first into space. A satellite known as a relay satellite then bounced the signals back to a different area on the earth. The picture on this page shows how a relay satellite works. What might be some other uses of a relay satellite?

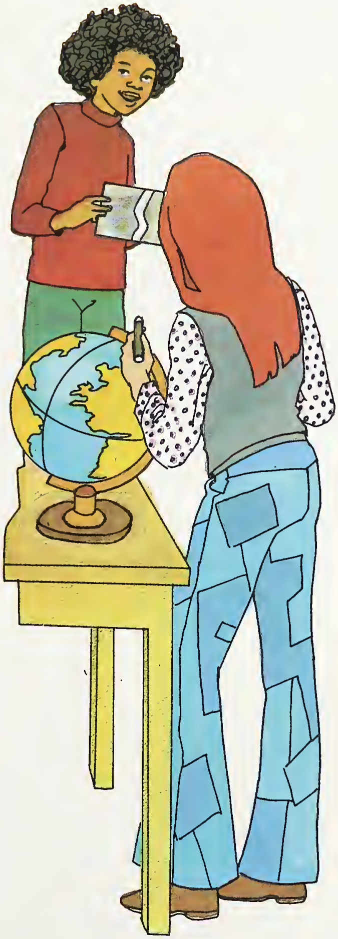
Besides orbiting satellites, there are other spacecraft sent into space. These spacecraft are sent to certain areas in the solar system. Different craft have been sent to probe, or explore, Venus, Mercury, Mars, Jupiter, and Saturn. Information about these planets and their moons has been sent back to the earth. Sometimes the information supports some of the ideas people have

Exploring on Your Own

Two spacecraft, *Pioneer 10* and *11*, have been sent out of the solar system. They were sent in hopes of finding other intelligent life forms in the universe. Find out what information was sent on the craft.



had about these planets. Other times the information comes as a surprise. Why do you think this might be so?



FINDING OUT

How can you show how relay satellites bounce signals back to the earth?

You will need: small mirror, globe, small flashlight

- Darken the room and choose a spot on the globe from which to send the signal.
- Have someone hold the mirror away from the globe. This mirror represents the relay satellite in space.
- Turn on the light and aim it toward the "satellite."

Which spot on the globe received the signal? Why?

- Choose other spots from which to send the signal.
- Move the relay "satellite" in orbit around the globe.

Can a signal be sent to any area on the globe? Why or why not?

- Move the relay "satellite" farther from, then closer to, the globe.

How did the receiving spot change when the "satellite" moved farther from the globe?
How did the receiving spot change when the "satellite" moved closer to the globe?

Early explorations. There were many successful launches of rockets into space in the late 1950's. At that time, a goal was set to send people to the moon and to return them safely back to the earth. The goal was given a ten-year deadline.

Because of this goal, many things had to be learned about life in space. Could living things from the earth survive in space? And if so, under what conditions? The first living thing to be sent into space was a dog. Although the dog was sent just for a ride, its barking was communication enough to prove that a living thing could survive in space.

Several chimpanzees were also sent into space on different flights. These chimps were trained to push a few buttons to test radio controls. When they pushed the correct buttons, they received banana rewards. This operation proved that earth-space communications were good and that the chimps could healthily respond in their space environment.

Moon visitors! In 1959, the first person sent into space was astronaut John Glenn. His fifteen-minute flight was the successful beginning for the ten-year goal.

Many other successful flights were made. Astronauts orbited the earth. They "walked" in space. They orbited the moon. Spacecraft met with other spacecraft. Spacecraft and astronauts returned safely to the earth.

In July, 1969, Neil Armstrong walked on the moon. He was the first astronaut to accomplish the goal set ten years earlier. Although Armstrong's steps on the moon were an end of a goal, there have been many more goals and explorations. What are some of these goals and explorations?

A Second Look

1. Why are telescopes used? What are two kinds of telescopes? How are they alike? Different?
2. What are some problems with very large telescopes? How are these problems solved?
3. What are some different kinds of satellites?
4. What were some events which led to sending people to the moon?

Workers Who Use Science

Each time a spacecraft is launched, the event is the result of the work of thousands of people. The people who work on space projects are called *aerospace workers.*

Aerospace workers represent all areas of science. Some of these workers study the atmosphere and space. They chart the movements of stars, moons, and planets. Aerospace designers plan and test the shape of rockets, satellites, and other spacecraft.

Other aerospace workers build and test various systems. These systems might be for air pressure control, heating and cooling, radio and television communication, or electrical power. When astronauts are in space, aerospace workers ensure that all systems are working.

After a spacecraft returns to earth, other aerospace workers study the soil and mineral samples collected. Others study the effects of being in space on people and equipment. This helps workers who plan future projects.

To find out more about aerospace workers, try to find answers to these questions:

How do aerospace workers solve problems of weightlessness?

What are some other space problems aerospace workers must solve?

How do aerospace workers chart the paths of rockets and spacecraft? Why is this important?

To help you answer these questions and others you may have about aerospace workers, you might write to the Canadian Aeronautics and Space Institute, 77 Metcalfe Street, Ottawa, Ontario K1P 5L6.

Reviewing the Main Ideas

The solar system is made up of the sun, nine planets, moons, asteroids, comets, and meteors.

The planets rotate on their axis and revolve around the sun.

The moon causes many changes on the earth.

Asteroids are small rocky or metal objects which orbit the sun in the asteroid belt. Some asteroids are found in Jupiter's orbit.

The violent hydrogen and helium explosions of the sun release light and heat energy.

The sun's corona, flares, prominences, and spots cause changes on the earth.

The sun directly affects all weather on the earth.

Telescopes and spacecraft have helped people learn many things about the earth and other parts of the universe.

Reading About Science

Asimov, Isaac. *Asimov on Astronomy.* Toronto, Ontario: Doubleday Canada Ltd., 1974.

Branley, Franklyn M. *Comets, Meteoroids, and Asteroids: Mavericks of the Solar System.* Don Mills, Ontario: Fitzhenry and Whiteside Ltd., 1974

Knight, David C. *The Tiny Planets: Asteroids of Our Solar System.* Agincourt, Ontario: Gage Publishing Limited, 1973.

Nicolson, Iain. *Astronomy*, ed. Georg Zappler, Don Mills, Ontario: Fitzhenry and Whiteside Ltd., 1970.

Simon, Tony. *Moon Explorers.* Richmond Hill, Ontario: Scholastic—TAB Publications Ltd., 1973.

Testing for Understanding

Ideas to Check

On your paper write *T* for each sentence below that is true. Write *F* for each sentence that is false.

1. At one time, people believed that the sun moved around the earth.
2. All planets revolve in circles around the sun.
3. A calendar month on the earth is the time the earth takes to revolve around the sun.
4. The asteroid belt is made up of small rocky or metal particles which orbit the sun between Mars and Jupiter.
5. All comets have tails stretching out behind their head.
6. Solar flares are disturbances on the sun, which can cause changes on the earth.
7. The sun's energy causes all changes in weather on the earth.

Words to Use

Write on your paper the word or words that best fit in each blank below. Choose from these words or groups of words: *Armstrong, Copernicus, Mercury, Mars, Jupiter, Venus, meteor showers, sunspots, red giant, reflector, rotate, revolve, corona, refractor.*

1. ____ was one of the first people who suggested that the earth moves around the sun.
2. Cool areas on the sun are known as ____.
3. A ____ is a stage of a star.
4. When the earth moves through an area where a comet has recently passed, ____ may occur.
5. All planets ____ on their axis.
6. A ____ telescope has mirrors to help form an image.
7. The outer area of the sun is called the ____.

Having Fun with Science

Earth II

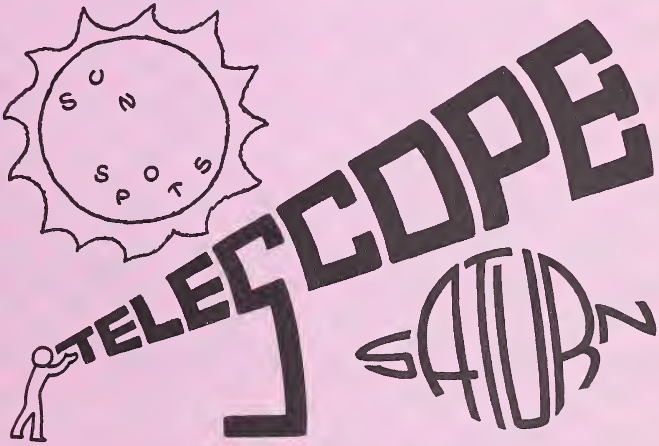
Suppose you were to travel to another solar system and find a life-supporting planet older than the earth. Write a story about such a trip. Tell about the planet and the life on it.

Sky Watch

Check local newspapers for the locations and viewing times of visible planets. Also check for the phase of the moon. Each night plot the movements of the planets and the moon. Chart their rising and setting times. Compare your findings with other sky watchers in your class.

Drawing Words

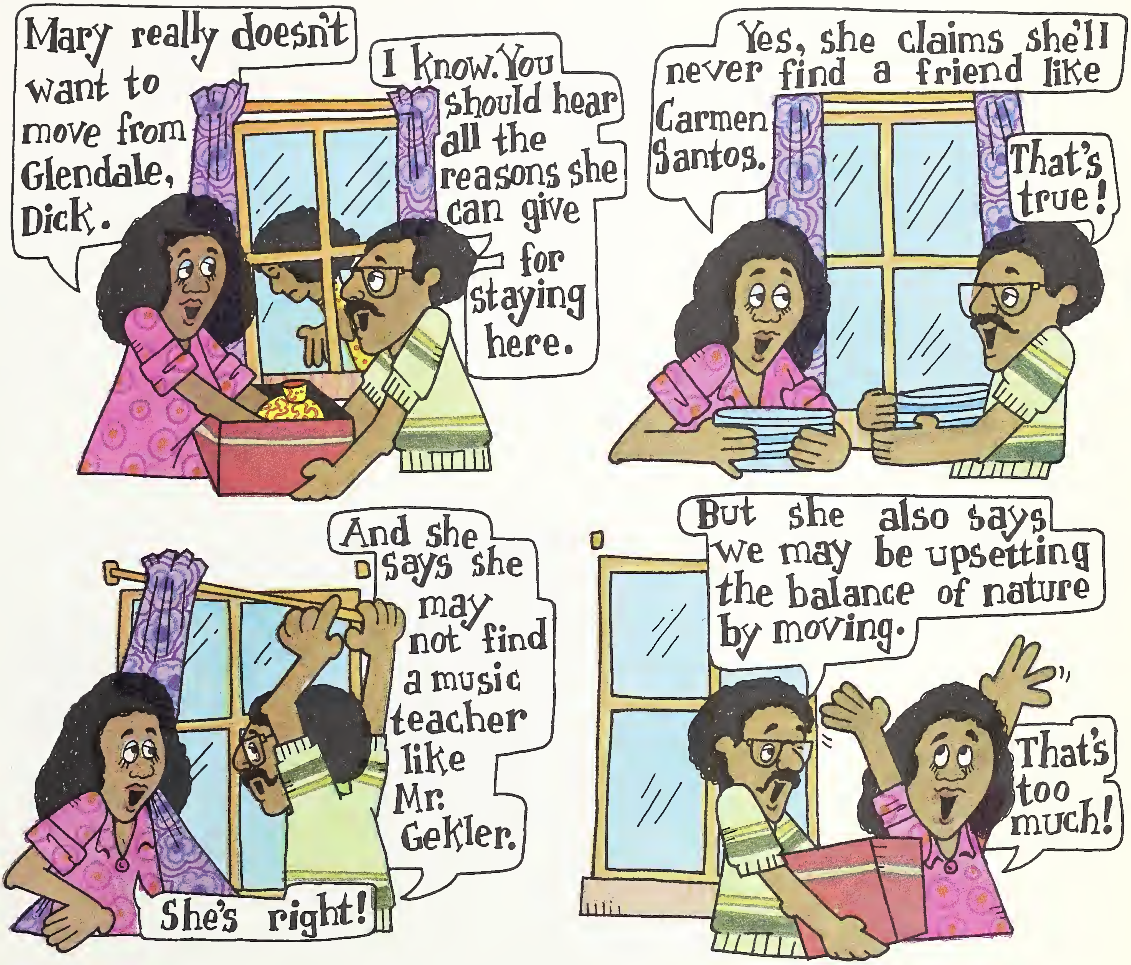
Some words can be written so they show their meaning.



How might you draw other words about the solar system?

6 Ecosystem Earth

1. Nonliving things in an ecosystem
2. Living things in an ecosystem
3. Balance in an ecosystem


Mary really doesn't want to move from Glendale, Dick.
I know. You should hear all the reasons she can give for staying here.
Yes, she claims she'll never find a friend like Carmen Santos.
That's true!
And she says she may not find a music teacher like Mr. Gekler.
She's right!
But she also says we may be upsetting the balance of nature by moving.
That's too much!

What do you think is meant by the balance of nature?

What are some ways that the balance of nature might be upset?

1 Nonliving things in an ecosystem

Have you ever taken a walk through a park? If so, you may have been aware of many things around you. Some of these things, like the squirrels and trees, are alive. Other things, like the sunlight and soil, are not. What are some other living and nonliving things you might find in a park?

The living and nonliving things in a park *interact* with one another. That is, they each affect one another. For example, soil offers an earthworm shelter and food. An earthworm enriches the soil with its wastes, which contain many minerals. An earthworm also helps break down the decaying matter in soil. In what other ways do the living and nonliving things in a park interact?

The study of the interaction between living things and their surroundings is known as *ecology* [ih-KOL-uh-jee]. The interaction of living and nonliving things in a place is called an *ecosystem* [EE-koh-SIHS-tuhm]. A park is an ecosystem. A pond is an ecosystem. The entire earth is an ecosystem. How are these ecosystems alike? How are they different?

Soil

One nonliving thing in many ecosystems is soil. You feel it under your feet. You use it when you want to grow something. Soil is very important for growing things because it has minerals that plants need. Soil also holds water that plants need. What do you think the earth would be like without soil?

Although many ecosystems have soil, some may not always have had soil. Suppose you were on a ship exploring the ocean for uncharted islands. You might come upon a new island like Surtsey. Surtsey is an island that was recently formed off the coast of Iceland. At first your new island would hardly be an ecosystem. It might surprise you that the new island is just rock with no soil.

If you could stay on the island awhile, the island would gradually begin to change. The ocean would

A volcano under the ocean erupted to form the island of Surtsey. How do you think a volcano can form such an island?

wash sand up on the shore every day, bringing the first trace of soil. Living things would be washed up on the island, too. The living things would grow, reproduce, and die. After they died, they would decay. The decayed matter would add to the soil. Rainfall would wear some of the rocky surface down, helping to make more soil for the island. In what other ways might soil be formed?

Even if you could stay on the island for a long time, however, you might not find much soil forming beneath your feet. It takes hundreds of years for just one inch of soil to be formed. Why do you think it takes so long for soil to be formed?

FINDING OUT

How can you make soil?

You will need: several small rocks of different kinds, coffee can with lid, water, small seeds (like mustard or radish), can of garden soil

- Place the rocks in the can. Put about 3 cm of water in the can. Cover the can.
- Shake the can very hard about 100 times.
- Give the can to 5 friends and have them do the same thing.

What do you see forming at the bottom of the can? How might this same thing happen in nature?

- Try rubbing some of the rocks together in your hands.
- Try breaking your rocks down in other ways.

Which of these ways is best for breaking the rocks down?

- Plant some of the seeds in the "soil" you made.
- Plant the other seeds in soil from a garden.
- Water the sprouting plants as needed for 2 or 3 weeks.

Which plants grew better? Why?

Water

Another thing which is an important part of an ecosystem is water. Which ecosystems do you know of that have a lot of water? Which ecosystems have very little water?

Being part of things. One way in which water is important is that each living thing in an ecosystem is made mostly of water. There is water in every part of your body. In your bones. In your muscles. The fluids in your body are made mostly of water. What are some of these fluids? Why are they important?

Water makes up much of the body of most plants and animals in an ecosystem. Why do you think living things need so much water in their body?

About three fifths of this boy's body weight is water. What are some of the things that make up the rest of his body weight?

Dissolving things. Suppose you stir some sugar into a glass of lemonade. You know that the sugar seems to disappear. The water in the lemonade dissolves the sugar. Water dissolves many things. Because of this, water is very important to living things in an ecosystem.

Plants need many minerals that are in the soil. Water dissolves these minerals. Then when the plants take in water through their roots, they also take in the minerals which are dissolved in the water. Water also makes it possible for the minerals to move from the roots to other parts of the plant.

Water also helps dissolve some of the food animals eat. Many body fluids, such as saliva, help dissolve food. And many of the chemicals in the stomach and intestines that help digest an animal's food must be dissolved in water so the chemicals can work.

Making food. Water is important to some plants in another way. Green plants must have water to make their own food. With the help of sunlight and chlorophyll, green plants use water and *carbon dioxide* [dy-OK-SYD], a gas in air, to make a kind of sugar in their leaves. Water then helps plants by carrying the sugar to other parts of the plants. This food gives the plants the energy they need to grow. How might the food that plants make be important to some of the animals in an ecosystem?

Air

You probably know that many spaceships have been sent to outer space. One of the reasons for this is to study other planets. People want to know what things might be found on these planets. They want to know if other planets have soil or water. They also want to know if other planets have living things on them. But, of course, for living things to be on other planets, the planets would also have to have air. Almost all living things we know about need air in order to live. If some other planets have air, water, and soil, they might also have ecosystems there.

Some living things in an ecosystem could live for many days without water. But most of them could not live for more than a few minutes without air. Air has a gas called *oxygen* that living things need. Without oxygen, the cells of living things would stop working. How are astronauts able to travel in space, where there is no oxygen?

In addition to oxygen and carbon dioxide, another gas in air is *nitrogen* [NY-truh-juhn]. Plants need nitrogen to make new cells as they grow.

Most living things get the gases they need by taking in air. How do you suppose living things in a water ecosystem, such as a lake, get the gases they need?

The earth's layer of air is visible in this picture from space. Suppose another planet has gases around it. Could you be certain that there is life on that planet? Why or why not?

Energy

At some time or other you have most likely had toys that moved. Your toys may have even lifted things or walked. But they couldn't move by themselves. You had to wind them up or turn on their batteries. In order to move, things need energy. As you may know, energy is the ability to cause change. Where do you get the energy you need to run or to ride a bike?

Winding up an ecosystem. Ecosystems need energy, too. The energy for all ecosystems comes from the sun. The sun is very important in deciding the kind of *climate* an ecosystem has. Climate is the kind of

weather a place has for a long period of time. For example, the climate in some deserts is hot and dry. The climate in some forests is cool and moist.

One way the sun affects the climate in an ecosystem is by heating the air. When some air is heated more than other air, the warmer air rises. The cooler air moves down. When air moves, winds are formed. How might wind affect living things in an ecosystem?

Another way the sun affects an ecosystem is by causing rain. The sun heats the water in the oceans, lakes, and rivers. This causes the water to turn into water vapour. Water vapour is light and rises to help form clouds. When clouds are cooled, the water vapour turns back to water again, and it falls as rain.

The living things in an ecosystem get energy from the sun, too. The sun helps green plants make food. The food that plants make has energy from the sun "locked" inside it. When animals eat green plants, they get the energy from the food the plants make. Why do animals need energy?

Storing energy beneath the earth. As brought out, plants are an important part of an ecosystem. At one time, the land areas of the earth were almost covered with plants! But all of these plants were not eaten by animals. Nor did they decay after they died. Many of them became buried beneath the earth. There these plants changed in another way. After millions of years, the buried plants were turned into coal or oil. Energy that was once in plants is now stored in coal and oil.

Today, people have learned to adapt to whatever ecosystem they are a part of. To do this, people often need energy other than that which they get

Exploring on Your Own

Energy from the sun is stored in coal and oil. Many people think that using energy directly from the sun might help solve many energy problems. Try to find out the problems involved in capturing energy from the sun. Also try to find out what progress has been made. Look in a reference book under the heading *solar energy.*

from eating food. They need energy to heat their home and run their machines. When coal or oil is burned, energy is released to do these things. What other sources of energy might people use in adapting to their ecosystem?

A Second Look

1. What is an ecosystem?
2. What are some of the nonliving things in an ecosystem?
3. In what ways is water important to living things in an ecosystem?
4. Where does the energy for an ecosystem come from?

2 Living things in an ecosystem

You have seen how some of the nonliving things, like soil, water, air, and energy, are important to an ecosystem. These nonliving things influence the kind of ecosystem that will exist in a given place. But living things also influence many things about an ecosystem.

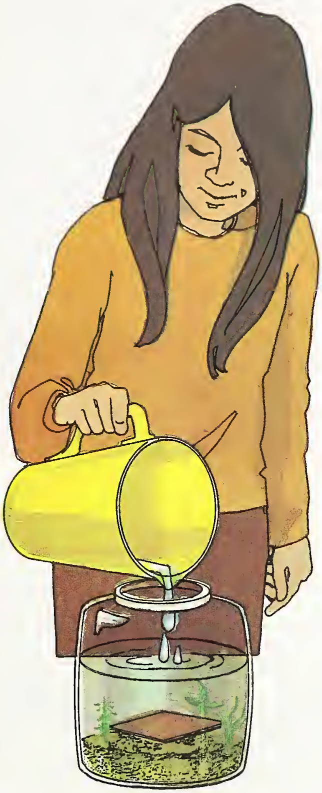
Interactions in a freshwater ecosystem

Have you ever gone fishing in a lake or a stream? If so, you probably know of the many nonliving things that make up a freshwater ecosystem. You may have felt the cool water, the warm sunshine, and the smooth rocks that are found in this kind of ecosystem.

You may also have noticed that some of the rocks in a stream or a lake are covered with something green. The green material is made up of plants. Many of these plants do not have stems or roots. They are called *algae* [AL-jee]. Algae are very simple plants. They can get most of the things they need to live and grow from the water and the sun.

Also clinging to the rocks are the young of many insects. These young insects are especially well adapted to a freshwater ecosystem, in which the water may move swiftly. They have strong claws, which save them from being washed away.

Fish are also found in many freshwater ecosystems. Fish have gills, which help them breathe in water. Many fish feed on algae or the young of insects found in water. Bigger fish eat smaller fish. What are some other living things which might be found in a freshwater ecosystem?



FINDING OUT

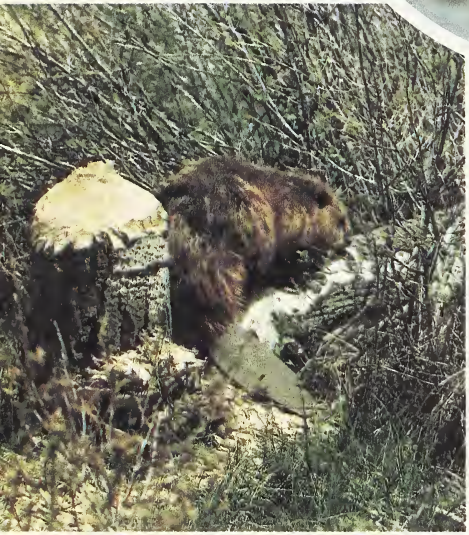
What is life in a freshwater ecosystem like?

You will need: widemouthed 4 L jar, water, sand, pond plants, guppies or goldfish, fish food, snails, cardboard

- Pour about 3 cm of sand in the jar. Put the plants firmly in the sand.
- Put the cardboard on top of the sand and slowly fill the jar with water. Remove the cardboard. Let the water stand for 24 hours. This allows chlorine gas in tap water to escape from the water.
- Put several guppies in the water. Add the snails.
- Put the freshwater ecosystem in a place that has light, but not direct sunlight. Feed the fish every day.
- Observe your freshwater ecosystem for a week.

How do the living things in your freshwater ecosystem depend on the nonliving things?
How do you think the living things depend on each other?

Changes in a freshwater ecosystem. Sometimes a stream may grow deeper as it cuts through the land. Or a stream may slow down and widen. Something in its way may even make a stream change its course. A stream may also dry up. When a stream changes in any way, the plants and animals living in the stream are affected.



Sometimes the living things in a freshwater ecosystem can cause changes in the ecosystem. For example, beavers change a pond or a stream when they build a dam. The beavers cut down trees along the water's edge. They use the trees for building the dam.

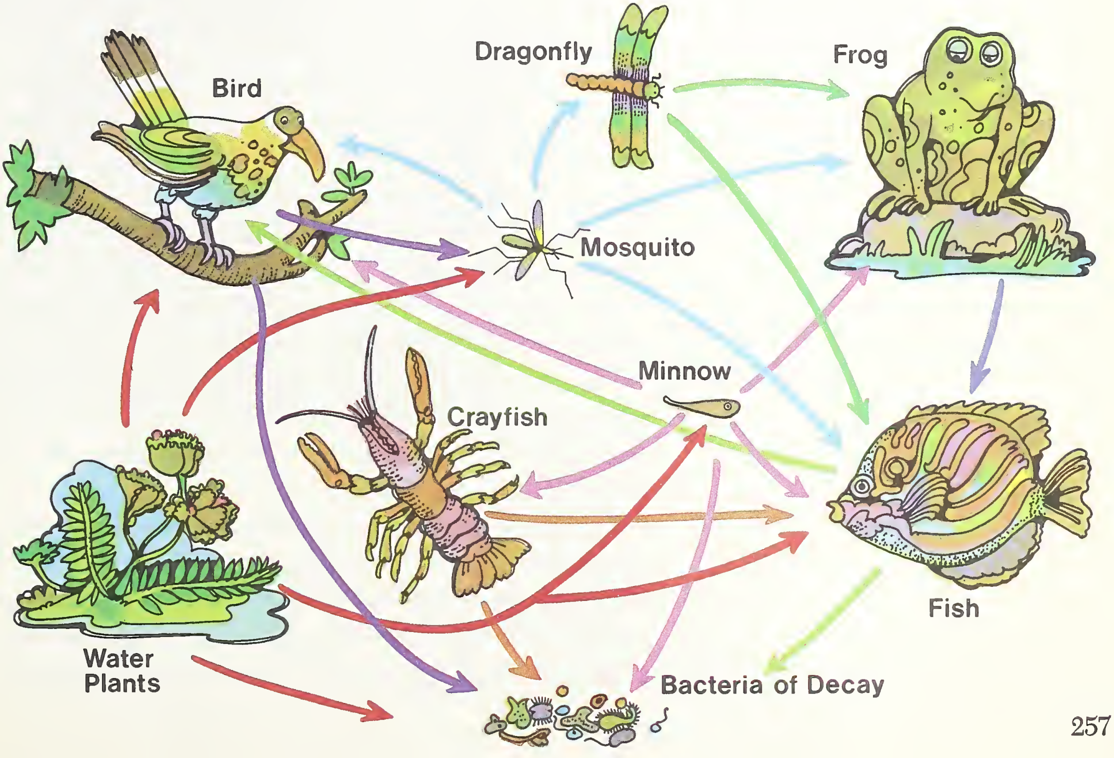
As the dam makes the pond deeper, some animals, like tiny shrews, have to leave the pond. They escape to a place where the water is shallower. But other animals that like deeper water, like some fish, are attracted to the pond. Because of them, birds which eat these fish soon flock there, too. New water plants begin to grow in the area. And animals that eat these plants will soon have a good supply of food.

What are some other changes that might take place in a freshwater ecosystem? What might cause these changes?

Food webs in a freshwater ecosystem. You may have noticed that animals are often found near the food they like to eat. Some animals eat plants. Other animals eat the animals that eat plants. It's like a chain with each plant or animal being a link, or part, of the chain. Some people call this a *food chain.* The food-chain idea suggests that each animal has only one plant or animal which it eats.

But, in nature, each food chain is also part of other food chains. And since food chains often cross, something like a web better describes what living things eat in an ecosystem. The picture on this page shows a *food web* in a freshwater ecosystem. What other things might you add to the food web?

The arrows show where the food for each of these animals comes from. How might you explain the arrows leading to the bacteria?



Interactions in a desert ecosystem

Suppose you had to spend a day in a hot desert. You would find it very different from a freshwater ecosystem. A desert has very little water. You might have to carry water with you.

Most deserts, however, have more of another nonliving thing than any other kind of ecosystem. This thing is sunlight. These extremes, little water and much sunlight, can show how very important nonliving things can be to the activities of living things in an ecosystem.

Overcoming the heat. Many animals that live in a hot desert must protect themselves from the heat and dryness. So they live either in burrows beneath the ground or inside plants. The animals stay in the ground or in the plants during the day.

When the hot sun sets, the desert comes alive. Desert birds hop out of holes they have made in giant cactus plants. For a few hours they hunt for insects and seeds. A kangaroo rat may spring out of its burrow in the ground to gather seeds. A snake, fresh from its burrow, may be ready to strike the kangaroo rat in the darkness. A roadrunner, a bird that runs fast, may just happen by to snatch up the snake.

You can probably see that the kangaroo rat, the snake, and the roadrunner are each part of a food web. What other strands of this food web in the desert can you think of?

You have heard of some animals, like bears and groundhogs, sleeping through the cold winter. Some animals in the desert, like toads and snails, sleep through the hot summer. Both of these desert animals make a jellylike substance to cover themselves so they will

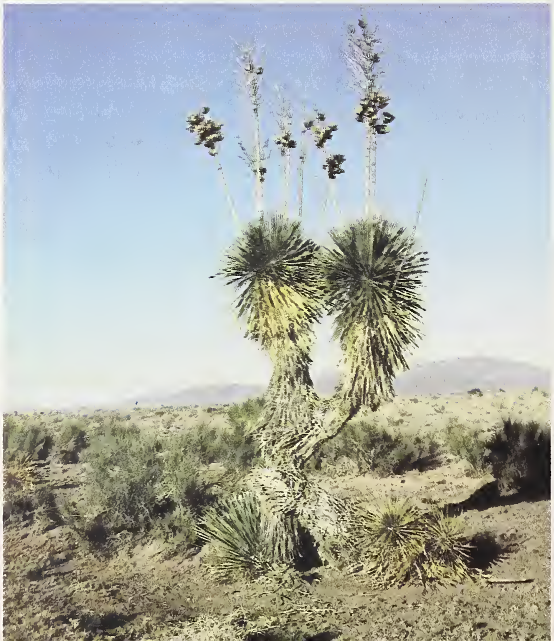
The Gila monster (above) is a poisonous lizard that feeds on snake and bird eggs. What time of day do you think would be best for it to collect the eggs? Why?

not dry out. Some birds also go into a sleep to help them through the heat. When it gets cooler, these animals become active again. In what kind of an ecosystem might extreme cold affect the activities of plants and animals?

Making the most of little water. Plant activity is very different in a desert ecosystem from that in a freshwater ecosystem. This is because there is very little water in the desert. Most plants lose large amounts of water through their leaves every day. But plants in the desert lose very little water. Some plants, like the cactus, have thin spines for leaves. Not much water is lost through the spines. The cactus plants also store water in the juicy part of their stem. How do you suppose spines protect a cactus from "unfavourable interactions" with animals?

Desert plants often have many roots close to the surface of the ground. These roots can quickly drink in the water when it rains. Some desert plants have both shallow roots and deep roots. The deep roots seek out the water deep in the ground. The shallow roots soak in the latest rain.

How might the stiff, narrow leaves of the candlestick yucca in the picture on the right help it survive in the desert?



The small amount of water available in the desert also affects the activity of animals there. Desert animals, like lizards, often get the water they need from eating juicy plants. Lizards also get water from the dew that forms on plants at dawn. One desert animal, the kangaroo rat, never needs to drink water. It gets the water it needs from the seeds it eats, even though the seeds may be dry. And a kangaroo rat never sweats!

Camels, which live in the deserts of Africa and Asia, can go without water for eight days or more. When camels have no water to drink, their body shrinks. But after they reach an oasis and drink a lot of water, they regain their normal body weight. Where do you think the water in a desert oasis comes from?

Reacting to rain. In some deserts it may rain just once a year. In other deserts it may rain only every four or five years. But, when it rains, things change rapidly in the desert. A whole new cycle of plant life begins. Seeds that were in the soil mix with the gravel and rainwater. This rough mixture helps tear off the seed coats that had been protecting the seeds. This makes the seeds sprout very quickly. Within a few weeks, the plants produce fruits and seeds. But the new seeds may have to wait a few years to sprout. Why?

Animals in the desert also start a new cycle of life after the rain. The new growth in plants provides more food for the animals. This new growth seems to help "trigger" the animals to have their young. Toads lay their eggs at that time in the puddles and pools left by the rains. Soon tadpoles are wriggling in the water. A week later, the young toads dig into the mud. This keeps them from drying out as the puddles and pools dry up.

Birds also mate just after the rains. When the young birds are growing, there are plenty of insects to eat. These insects come out of hiding after the rains to feed on the new green plants. What other changes can you think of that might happen in a desert after a heavy rainfall?

Interactions in a city ecosystem

When someone mentions the word city, people tend to think of tall buildings and many cars. Some people may not think of a city as an ecosystem. But think of all the things plants need to grow. Which of these things can be found in a city? Think of the things animals need to live. Which of these things can be found in a city?

Plants in the city. Small plants, like grass and weeds, are often seen in the city. Even bits of dirt in a crack of a building or pavement may be a place for tiny plants to grow. Climbing plants, like ivy, often cover old brick or stone buildings in the city. The seeds of many kinds of plants are carried to the city from a forest or a meadow by the wind or by birds.

FINDING OUT

How might a city ecosystem begin?

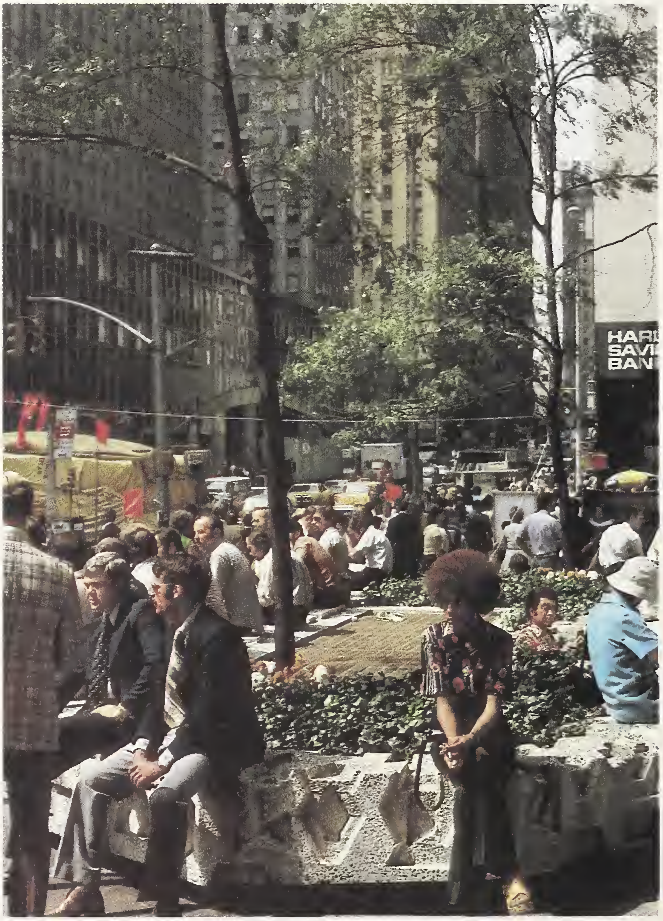
You will need: sterilized soil (from a flower shop), large clay pot, small stones

This activity can be done anytime except winter.

- Put a layer of stones in the clay pot.
- Fill the pot with sterilized soil. By using sterilized soil you make sure there are no growing plants present at the outset.
- Put the pot on the windowsill outside. Keep the soil moist. Wait a few weeks.

Have any plants grown in your pot? If so, where do you think the plants came from?
Do you think animals will become a part of this city ecosystem? Watch and find out.

Many trees grow well in the city. Of course, the trees that are the best city dwellers should not have deep roots. Many poplars once grew in cities. But then it was discovered that poplars send out many deep roots to any water underground. So people have replaced poplars with other kinds of trees. Why do you suppose they have done this?



Animals in the city. Many animals have made their home in the city. Squirrels use the trees in the city for their home and for their food. The squirrels eat the berries and nuts made by the trees.

Insects, the most numerous of all animals, are also found in great numbers in the city. A tiny piece of land, even near a busy street, may be inviting to many kinds of insects and other small animals. Insects have also moved into buildings and homes. Ants can live very well in buildings or wherever there is food. Cockroaches are also firmly settled in many buildings. Which insects have you seen in buildings?

Many birds also live in cities. Some birds build their nest in trees. Others build their nest in cracks of buildings and in monuments.

Exploring on Your Own

Some birds seem to be very well adjusted to city life. Try to find out which birds are usually found in the city. Look in a reference book under the heading *birds in the city*.

Many cities have more rodents, like mice, than they have people. Mice often get into buildings. They build nests between the walls of the buildings. Mice come out at night to find food. What city animals feed on mice?

FINDING OUT

What living things can you find in a vacant lot or field ecosystem?

You will need: string, 4 twigs, ruler, bucket, paper towels, vacant lot or field

- Mark off a rectangle about 15 cm by 30 cm in the lot or field.
- Observe as many living things in your ecosystem as you can.
- Dig down 10 cm and place the soil from your ecosystem in the bucket.
- Then carefully empty the soil, bit by bit, on the towels. Look carefully through all the soil.

What kinds of plants did you find in your ecosystem? What kinds of animals did you find?

- Be sure to return the soil to the lot or field when you are finished.

Why do you think you should do this?

You may never see many of the animals that live in the city ecosystem. This is because many of them only come out at night. Besides mice, racoons and skunks are other night animals that might be found in a city. Which animals do you know of that are part of a city ecosystem?

A Second Look

1. What kinds of living things live in a freshwater ecosystem?
2. What is meant by a food web?
3. How do some of the nonliving things in a desert ecosystem affect the activities of the living things there?
4. What makes a city ecosystem different from other ecosystems?

3 Balance in an ecosystem

Have you ever made pancakes or watched someone making them? If so, you probably know that sometimes you may add too much milk. The pancakes then turn out too thin. At other times you may add too much flour. The batter then becomes stiff, and the pancakes are too thick. To get the kind of pancakes you like, you need the right balance of milk and flour.

In an ecosystem things must also be balanced. That is, there must be enough of the nonliving things, such as water and air, for the plants and animals that are part of the ecosystem. Animals in an ecosystem must be able to find enough food. Plants must be able to get enough of what they need to make their own food. In what other ways must an ecosystem be balanced?

What nonliving things does this alligator need in its ecosystem? How might the alligator help keep some of the living things in its ecosystem in balance?

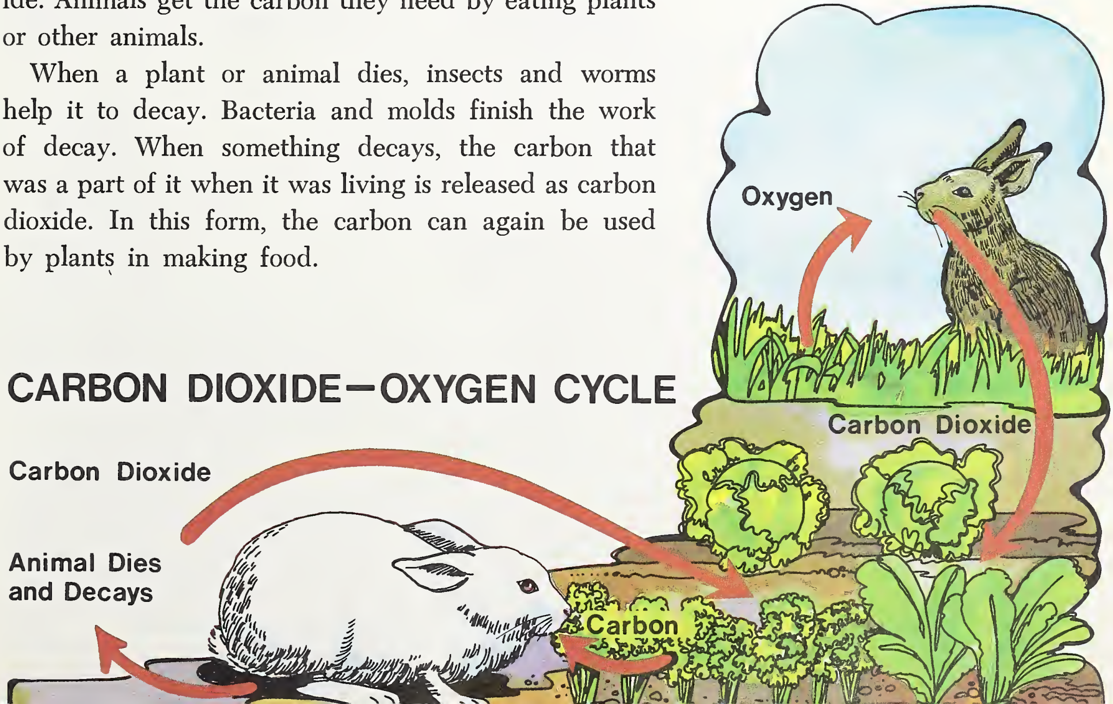
Balance of nonliving things

Think for a moment about the clothes that you wear. You don't usually wear them once and throw them away. You wash them and wear them over and over again. In an ecosystem some of the nonliving things are also used over and over.

Carbon dioxide–oxygen cycle. All living things in an ecosystem take oxygen from the air into their body. They give off carbon dioxide when they breathe out. Besides this, plants take in carbon dioxide to use in making their own food. They give off oxygen when they make food. All of this makes a kind of a cycle.

You may know that one part of carbon dioxide is the element carbon. Carbon is a very important part of the cells of all living things. Plants get the carbon they need from the food they make from carbon dioxide. Animals get the carbon they need by eating plants or other animals.

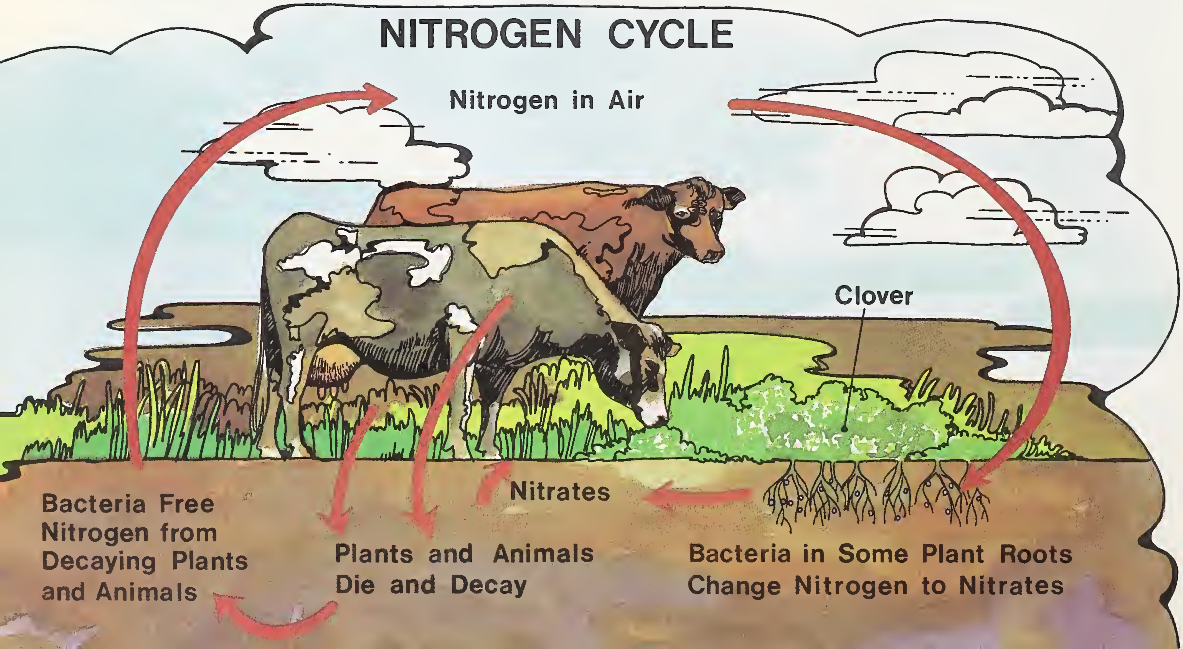
When a plant or animal dies, insects and worms help it to decay. Bacteria and molds finish the work of decay. When something decays, the carbon that was a part of it when it was living is released as carbon dioxide. In this form, the carbon can again be used by plants in making food.

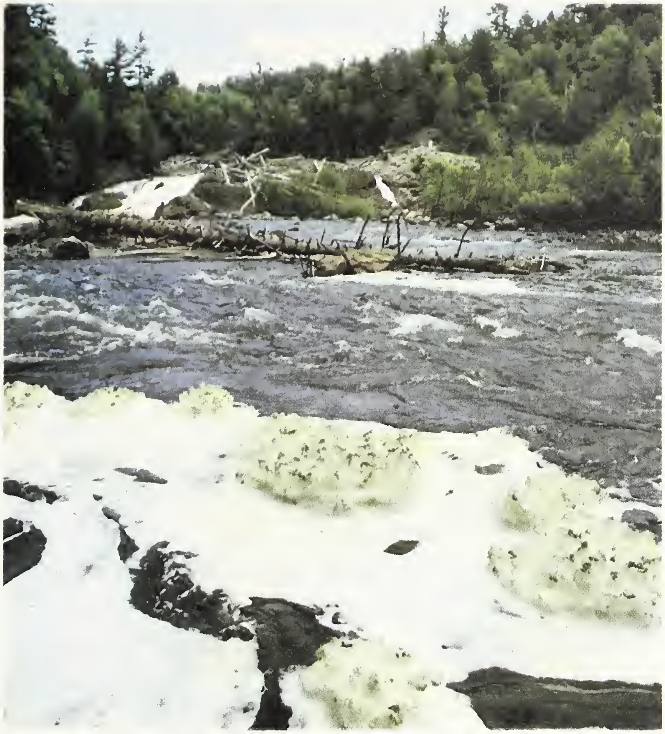


CARBON DIOXIDE—OXYGEN CYCLE

Nitrogen cycle. Besides carbon, another important element in all living things is nitrogen. As brought out before, nitrogen is another gas found in air. But, although there is very much nitrogen in air, living things cannot directly use the nitrogen as it is in air. Certain bacteria that live in the soil and in some plants can combine the nitrogen in the air with other chemicals. They are combined to make something called *nitrates* [NY-TRAYTS]. Nitrates provide plants with the nitrogen they need to grow. How do you think animals get the nitrogen they need?

Nitrogen from decayed plants and animals gets back into the air with the help of other bacteria. The picture on this page shows the importance of bacteria in the nitrogen cycle. What would happen to the nitrogen cycle if there were no bacteria?


NITROGEN CYCLE
Nitrogen in Air
Clover
Nitrates
Bacteria Free Nitrogen from Decaying Plants and Animals
Plants and Animals Die and Decay
Bacteria in Some Plant Roots Change Nitrogen to Nitrates



Some things that pollute a river are very hard to clean up. One such thing is phosphate detergent. Why do you think laws have been passed against the sale of such detergents?

Water cycle. Sometimes things that are harmful to living things might get into a lake or a stream. The water is said to be *polluted* [puh-LOOT-uhd], or unclean. What things might pollute a lake or stream?

By means of the water cycle, some of this polluted water can be purified. As you may remember, when water is heated by the sun, it turns into water vapour. Water vapour leaves all the impurities behind as it rises. Later, water vapour turns back into water and falls to the earth as clean rainwater. It may help fill a lake or stream. Although water can be recycled in an ecosystem, it is still important to keep from polluting water. Why?

Balance of living things

You have seen how some nonliving things are kept in balance in an ecosystem. Living things are kept in balance, too.

Checks on animals. In a forest ecosystem, the number of moose that could live there might be very large. There would be plenty of plant food for the moose. Of course, if the moose continued to increase in number, they could gradually destroy the forest. But this generally doesn't happen. Wolves feed on moose. The wolves keep the number of moose down, so that the forest can handle them. What might happen if all the wolves were killed?

Sometimes the number of jackrabbits increases in a certain ecosystem. The rabbits themselves begin to feel overcrowded as they compete for food. When this happens, the rabbits produce fewer young rabbits. Soon there is enough food for all the rabbits again. How else might the balance of animals in an ecosystem be kept?

Suppose a forest fire were to destroy many parts of this animal's ecosystem. What things might happen to the moose?

Checks on plants. Plants are also kept in balance in an ecosystem. Sometimes plants produce many seeds. If all the seeds fall in one area, there will not be enough room for the sprouting seeds. There will not be enough water and minerals in the soil for the young plants. So, some will die. This will help keep the right balance of plants in the ecosystem. In what other ways is the balance of plants in an ecosystem kept?

People in an ecosystem

There are many ways that balance is kept in an ecosystem. People often have a lot to do with the balance in an ecosystem.

Upsetting the balance. When people first came to Canada, they found rich soil in which to grow their food. In some places they had about 23 cm of good topsoil to plant crops in. Now in these same places farmers have only about 15 cm of topsoil to use for crops. Careless farming has allowed 8 cm of soil to be washed away by rain or to be blown away by winds. As you may remember, it takes a long time for new soil to be formed.

The early settlers in Canada also cleared many forests in order to plant crops. How might this have upset the balance in a forest ecosystem?

Even today people upset the balance in ecosystems. Sometimes factories are built near a river. The waste products from these factories are dumped into the river. The fish in the river might no longer be able to get the oxygen and clean water they need. This may cause the fish in the river to die. How might this affect the

Exploring on Your Own

Although heat energy is necessary for an ecosystem, some ecosystems can get too much heat. A river near a factory may be fed very warm water that has been used to run the machines. The water may be so warm that some living things in the river cannot survive. Try to find out other ways that rivers are polluted by heat. Try to find out how heat pollution affects survival and interaction in an ecosystem. Look in a reference book under the heading *pollution*.

balance of other animals in the river? How might this affect the balance of plants in the river?

Sometimes people spray their crops with insecticides to kill insects that feed on their crops. Birds that eat these insects may be harmed by the insecticides. The crops themselves may absorb some of the insecticides. When you eat something made from these crops, such as cereal, you may be harmed by the insecticide.

Harmful gases from cars and trucks may also upset the balance in an ecosystem. When engines give off harmful gases, the air becomes polluted. Why might this be harmful to the living things in an ecosystem?

Exploring on Your Own

Insecticides kill harmful insects. They can also kill many harmless animals. Many people are searching for new ways to control insects. Try to find out how some insects are controlled without the use of harmful insecticides. Look in a reference book under *organic gardening*.

FINDING OUT

How does smoke affect plants and animals in an ecosystem?

You will need: several grasshoppers or other large insects, 2 small potted plants, 4 x 4 L jars with lids, 10 small pieces of incense, matches

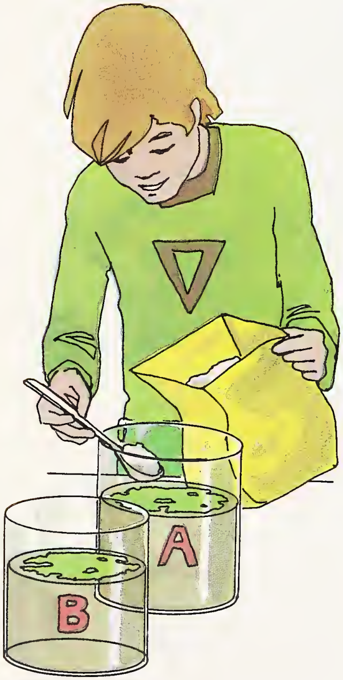
- Place 2 insects in 1 jar and 2 insects in another jar.
- Place 1 plant in a jar and the other plant in another jar.
- Place 1 piece of incense in 1 insect jar and another piece of incense in 1 of the plant jars.
- Light the incense. Leave the other 2 jars clear.
- Keep all 4 jars capped. Keep the jars where they all get the same heat and light.
- Light the incense in the same jars once every day.
- Observe your plants and animals each day.

How does the smoke affect your insects and plants?

Keeping the balance. Many people now realize that they must do what they can to keep things balanced in their ecosystem. Many people are driving less or driving in car pools to keep from polluting the air. New cars are being built which give off fewer harmful gases into the air. Factories are also finding ways to keep from polluting the air.

Another way people can make the air cleaner is by using cleaner fuels in factories and cars. To be able to do this, people are looking for new sources of energy. They are studying how energy from the sun might take the place of other kinds of energy. People are studying how to make use of nuclear energy. What things do you know of that are being run by nuclear energy?

Many factories near rivers have been making greater efforts to find new ways to dispose of their waste products. Laws have been passed by which factories that pollute the ecosystem can be fined.



FINDING OUT

What happens when phosphate pollutants get into a freshwater ecosystem?

You will need: pond water with algae, phosphate fertilizer (from a flower shop), 2 glass jars, tablespoon

Sometimes phosphate fertilizers which run off the land can pollute a freshwater ecosystem.

- Put half the pond water in 1 jar. Put the other half in the other jar.
- Add 1 tablespoon of the phosphate fertilizer to 1 jar. Label this jar "A." Label the other jar "B."
- Put both jars in the light, but not in direct sunlight. Wait for 2 or 3 weeks.

In which jar do algae from the pond seem to be growing more rapidly?
Why might too many algae in a freshwater ecosystem be a problem?

People are also aware that many living things in the ecosystem, like tigers and whales, have been reduced in numbers because of overhunting. It is hoped that stricter laws about hunting will save these endangered animals. Why is it important to save animals? What other ways do you know of to help keep the balance in the ecosystem?

This female tiger will do what she can to raise her cub so that it can become an adult tiger. What things might people do to help this come about?

A Second Look

1. Which nonliving things are used over and over in an ecosystem?
2. How do living things control the numbers of other living things in an ecosystem?
3. What are people doing to help keep the balance in the ecosystem?

Workers Who Use Science

Many people are concerned about the ecosystems of the world and the problems which they face. In fact, it is the job of some people to study ecosystems. These people are *ecologists* [ih-KOL-uh-juhsts].

Ecologists try to find out what natural things might upset the balance in an ecosystem. Suppose they are studying an ecosystem where crops are very important. Ecologists then try to foresee anything that might harm the crops, like a long period without rain or a plague of grasshoppers. Their studies may help save the food supply for the people and animals in the ecosystem.

Ecologists also study how people have upset the balance in an ecosystem. They study how harmful gases from cars and factories affect an ecosystem. They have also done much to keep some factories from dumping their waste products into rivers.

Some ecologists also study how certain kinds of animals are in danger of dying out because of overhunting. They study just how many of these animals can be hunted within a year. Ecologists have worked to have laws passed, protecting the numbers of these animals.

To find out more about ecologists, try to find answers to these questions:

How else can ecologists be helpful in keeping the balance in ecosystems?

What are some other things that ecologists study about an ecosystem?

You may wish to use reference books or write to the
Environmental Protection Service, Ottawa, Ontario,
K1A 0H3.

This ecologist is studying the effects of insecticides on tiny pond animals that she has collected. Why is this important?

Reviewing the Main Ideas

The interaction of living and nonliving things in a place is called an ecosystem.

Some of the nonliving things in an ecosystem are soil, water, air, and energy.

The energy for all ecosystems comes from the sun.

The kinds and amounts of nonliving things in an ecosystem help decide the kinds of living things that are part of that ecosystem.

A food web describes what living things eat in an ecosystem.

There are many kinds of ecosystems, including freshwater, desert, and city ecosystems.

In an ecosystem, living things must be in balance with each other and with nonliving things.

Some nonliving things can be used over and over in an ecosystem.

People can do many things to help keep the balance in an ecosystem.

Reading About Science

Adrian, Mary. *Wildlife on the Watch.* Don Mills, Ontario: Saunders of Toronto, 1974.
Hess, Lilo, *Small Habitats.* Rexdale, Ontario: John Wiley and Sons Canada Ltd., 1976.
Johnson, Sylvia. *Animals of the Deserts.* Don Mills, Ontario: J.M. Dent and Sons (Canada) Ltd., 1976.

Testing for Understanding

Ideas to Check

On your paper write *T* for each sentence below that is true. Write *F* for each one that is false.

1. The interaction of living and nonliving things in a place is called an ecosystem.
2. All living things in an ecosystem need water.
3. The energy for all ecosystems comes from the sun.
4. People sometimes upset the balance in an ecosystem.
5. Killing off one kind of animal in an ecosystem will probably not hurt the ecosystem.
6. Some kinds of energy are cleaner than others.

Words to Use

Write on your paper the word or words that best fit in each blank below. Choose from these words: *algae, food web, soil, air, polluted, water, ecology.*

1. A ____ describes what living things eat in an ecosystem.
2. When something is unclean, it is said to be ____.
3. The study of the interaction between living things and their surroundings is known as ____.
4. ____ is important to an ecosystem because it dissolves many things.
5. One nonliving thing in an ecosystem that takes a long time to be formed is ____.

Having Fun with Science

What Am I?

1. At eco-banquets I don't feast,
But I am food for man and beast.

2. People say I cause pollution.
Forming pools is one solution.

3. I'm earth's soft cover in which seeds
can sprout.
If people aren't careful, they may be
without.

Making a Food Web

Choose an ecosystem. Let's say you choose a desert ecosystem. Pass out small cards to about eight friends. Have them write the name of one plant or animal that can be found in a desert ecosystem on each side of the card. Have each player turn up one side of the card. Give one person a ball of string. That person should hold onto the end of the string and pass the ball of string to someone with a card that has the name of an animal that would eat the plant or animal that is on the first person's card. That person then holds onto the string, but unravels the ball and passes it to another person who has an animal that would eat the second animal. The object of the game is to pass the ball of string to every possible eater of each plant and animal. Don't miss any possibility. It gets very complicated, just like a food web in nature. Turn the cards over and try the other food web. What might happen if one of the strands in these food webs is broken?

Glossary-Index

One of the purposes of this glossary-index is to help you pronounce and understand certain words in this book. Another purpose is to help you find out about topics in this book that may interest you. You can find out about a topic by turning to the page or pages given at the end of each topic that is listed.

In this glossary-index, the syllables of a word are separated by a space. This can help you say the word. A special spelling may follow a word. This spelling always appears in [ ]. This spelling can also help you say the word. When a word has two or more syllables, one syllable is stressed more than others. This syllable is always spelled with large capital letters, as in the word *gravity* [GRAV-uht-ee]. Syllables that are not stressed are always spelled with small letters. Sometimes a word has one or more syllables that are stressed, but not so much as the syllable spelled with large capital letters. Those syllables are spelled with small capital letters, as in the word *electricity* [ih-LEHK-TRIHS-uht-ee]. Words of only one syllable are also spelled with small capital letters, as in the word *nerve* [NURV].

Sometimes a syllable in a special spelling is placed inside ( ), as in the word *mineral* [MIHN(-uh)-ruhl]. This means that some people say the syllable when they say the word, but some people do not.

Below is a list of the letters and letter groups used for the special spellings. Across from each letter or letter group, you can read how most people say the letter or letter group.

Letter or letter group	Say like
a	*a* in *hat* [HAT]
ah	*a* in *father* [FAHTH-ur]
aw	*a* in *all* [AWL]
ay	*a* in *face* [FAYS]
ch	*ch* in *child* [CHYLD] and in *much* [MUHCH]
ee	*e* in *equal* [EE-kwuhl]
eh	*e* in *let* [LEHT]
eye	the first *i* in *iris* [EYE-ruhs]
g	*g* in *go* [GOH]
ih	*i* in *hit* [HIHT]
o	*o* in *hot* [HOT]
oh	*o* in *open* [OH-puhn]
oo	*oo* in *food* [FOOD] and *u* in *rule* [ROOL]
ow	*ou* in *out* [OWT]
oy	*oi* in *voice* [VOYS]
s	*s* in *say* [SAY]
sh	*sh* in *she* [SHEE]
u	*u* in *put* [PUT] and *oo* in *foot* [FUT]
uh	*u* in *cup* [KUHP]
ur	*er* in *term* [TURM] and *ir* in *sir* [SUR]
y	*i* in *nice* [NYS]
z	*s* in *degrees* [dih-GREEZ]
zh	*s* in *treasure* [TREHZH-ur]

Adapt: to adjust to your environment, 32–33, 35–36, 38–39, 44, 252
Adult: the stage in the life cycle of a living thing when it is able to reproduce, 62, 65–66, 70–71, 74, 77–81, 83, 85–90
Aero space work ers: people who work on space projects, 236
Air: 229–230, 248–249, 253; elements in, 121; needs of embryo, 58; and weather, 226, 236
Al che mists [AL-kuh-muhsts]: people who tried to change one element into another, 118–119
Al gae [AL-jee], 254
Al loy: a combination of two or more metals, 130–132
Amoe ba [uh-MEE-buh]: a one-celled animal, 53
Am phib i ans [am-FIHB-ee-uhnz]: animals which live part of their life cycle on land and part in water, 82–84
An i mals, 50–52, 54–56, 58, 60–62, 72, 74, 76–90, 254–256, 258–263, 265–269, 272, 274–275, 277
Arm strong, Neil: first astronaut to walk on the moon, 234
As so ci a tion [uh-SOH-see-AY-shuhn]: learning something because of a similar past experience, 35–36
As ter oids [AS-tuh-ROYDZ]: small rocky particles in space, 195, 206, 208–211, 215, 217
As tro nauts, 234
At oms [AT-uhmz], 114, 116–117, 127, 137, 170–171
Au ro ra: northern or southern lights, 225
Ax is: an imaginary line through a planet around which it rotates, 203
Bal ance: in ecosystems, 268–278; sense of, 13
Bat ter ies: 169; solar, 176, 181, 184
Black dwarf stage: stage of a star when all activity stops, 220
Brit tle ness: a special property of matter, 107

Car bon, 120, 128, 137, 269
Car bon di ox ide [dy-OK-SYD]: a gas in air, 28, 248, 269
Cells: tiny units of living matter that make up the body of living things, 52. *See also* Egg cell; Sperm cell.
Chem i cal [KEHM-ih-kuhl] **en er gy,** 147–149, 164, 169, 173, 175
Chlo ro phyll, 248
Cli mate: the kind of weather a place has over a long period of time, 250–251
Co chlea [KOH-klee-uh]: a part of the ear, 11
Col our: a special property of matter, 108 / and seeing, 9–11
Col our- blind, 10–11
Com ets [KOM-uhts], 195, 212—215
Com pound: matter made of two or more elements, 125, 127–128
Con di tioned re flex es: reflexes that are learned, 30–31
Con duc tiv ity [KON-DUHK-TIHV-uht-ee]: a special property of matter, 110–111
Con duc tor [kuhn-DUHK-tur]: matter which lets either heat or electricity pass through, 110–111
Cone- bear ing plants, 67–70
Cones: sensory neurons in the eye which help you see colour, 9
Con nect ing nerves: the nerves in the

spinal cord which carry impulses to the brain, 24
Co per ni cus [koh-PUR-nih-kuhs], **Ni co laus:** an astronomer who taught that the sun is the center of the universe, 195
Co ro na [kuh-ROH-nuh]: the halolike part surrounding the sun, 221

Den si ty [DEHN(T)-suht-ee]: the amount of mass in a certain volume, 106

Eclipse, 221–222
Ecol o gist [ih-KOL-uh-juhsts]: people who study ecosystems, 278
Ecol o gy [ih-KOL-uh-jee]: the study of the interaction between living things and their surroundings, 243–278
Eco sys tem [EE-koh-sihs-tuhm]: the interaction of living and nonliving things in a place, 243–278
Egg: a new cell formed when a sperm cell fertilizes an egg cell, 55–56, 58, 60, 77, 79–80, 82, 85–86
Egg cell: a female sex cell, 53–57, 59, 65, 68–69, 71, 74, 77, 79, 82, 85, 90
Elas tic i ty [ih-las-TIHS-uht-ee]: a special property of matter, 109
Elec tri cal [ih-LEHK-trih-kuhl] **en er gy,** 165–166, 168–169, 176, 178, 180–181, 184, 186
Elec tron: one of the particles of an atom, 114–115
El e ment [EHL-uh-muhnt]: matter made of only one kind of atom, 116–129, 131–132, 134, 136–137, 140, 213, 219, 221, 223 / symbol for, 118–120
El lip ti cal [ih-LIHP-tih-kuhl]: slightly oval in shape, 119, 212
Em bryo [EHM-bree-oh]: an early stage in the growth of a living thing, 56, 58–60, 65, 69–70, 74, 80, 85–87, 90
En er gy [EHN-ur-jee]: the ability to cause change, 146–188, 250–253, 276
En vi ron ment [ihn-VY-ruhn-muhnt]: surroundings, 8–47

Fe male: a plant or an animal having egg cells, 54, 58, 77, 79, 82, 85, 87, 90 / pinecones, 68–70. *See also* Egg cell.
Fer til iza tion [furt-uhl-uh-ZAY-shuhn]: the joining of a sperm cell and an egg cell, 55–59, 65, 74, 77, 79, 82, 85, 87, 90
Fish- cul ture tech ni cians, 92
Flow er: parts of, 71–74
Flow er ing plants, 71–75
Food: 58, 60–62, 65, 69–70, 74, 78, 83, 87–88; web and chain of, 257
Force: strength used to move something or to stop something from moving, 103
Fos sil fu els [FOS-uhl FYOO-uhlz]: coal, oil, and natural gas, 178–183
Fruit: the enlarged ovary of a flower, 74
Fu els, 149, 178–179, 181–182, 275

Gam ma [GAM-uh] **rays:** short, powerful rays of radiant energy, 163
Gen er a tor [JEHN-uh-rayt-ur]: a machine used to make electrical energy, 167–168, 172
Gills: the parts of a fish or young amphibian which help it breathe, 76, 82, 254
Glenn, John: first person sent into space, 234
Grav i ty: a force with which the earth pulls on all matter, 104, 201–202, 205, 209–210, 215–216
Grun ions [GRUHN-yuhnz]: small fish that reproduce in the sand on a beach, 79–80

Hal ley, Ed mund: an astronomer who plotted the orbit of a comet later named for him, 214–215
Heat en er gy, 153, 156, 169, 172–173, 175, 184–186, 219
Heat waves. *See* Infrared waves.
Her schel, Wil liam: a scientist who discovered infrared waves, 156
Hi ber nate, 83, 86

Im pen e tra bil i ty [ihm-PEHN-uh-truh-BIHL-uht-ee]: a common property of matter, 100
Im puls es [IHM-PUHLS-uhz]: waves of energy which travel along nerves, 24
In er tia [ihn-UR-shuh]: a common property of matter, 101–103
In fra red [IHN-fruh-REHD] **waves:** invisible heat waves, 156–157
In ter act: to affect one another, 242
Iris, 27

Kep ler, Jo han nes: an astronomer who plotted the movements of the planets around the sun, 195
Ki net ic [kuh-NEHT-ihk] **en er gy:** energy of a moving object, 150

Learn ing: conditioned reflexes and, 30–31; things that affect, 38–43; ways of, 32–37
Life cy cle: the stages of growth in the life of a living thing, 50–92
Light: 153; as a form of energy, 153–154, 156, 164, 169, 173, 176, 219; waves of, 154–155

Male: a plant or an animal having sperm cells, 54–55, 77, 79, 82, 85, 87, 90 / pinecones, 68. *See also* Sperm cell.
Mam mals, 87–91
Mass: the amount of matter in an object, 103 / density and, 106; different from weight, 104
Mat ter, 98–143, 146
Ma ture: to develop, 38–39
Me chan i cal [mih-KAN-ih-kuhl] **en ergy:** the energy of motion, 148–152, 167
Met al lur gists [MEHT-uhl-UR-juhsts]: people who work with metals, 140
Met als: certain elements found in the earth, 129–130, 132, 140
Me te or ites [MEET-ee-uh-ryts]: meteors which land on the earth, 216–217
Me te ors [MEET-ee-urz]: small metal or rocky objects which fall into the earth's atmosphere and streak across the sky, 195, 206, 215–217
Mi cro scopes [MY-kruh-SKOHPS], 52, 113
Mol e cule [MOL-ih-KYOO(UH)L]: smallest part of matter which still has the properties of that matter, 113–114, 137
Moons, 195, 204–208, 236
Mo tor nerves: the nerves which carry impulses from the brain and the spinal cord to muscles, 24, 28

Nerves, 22–31, 151
Ner vous [NUR-vuhs] **sys tem:** the system in the body made up of nerves, the spinal cord, and the brain, 22–24, 27, 32
Neu tron: one of the particles of an atom, 114
Ni trates [NY-TRAYTS]: compounds which provide plants with nitrogen, 270
Ni tro gen [NY-truh-juhn], 121, 137, 249, 270
Nu cle ar [N(Y)OO-klee-ur] **en er gy:** energy from the centre of an atom, 170, 172, 180, 183, 276

Nu cle ar re ac tor: a machine used to split apart the nucleus of an atom, 171–172, 180–181, 183
Nu cle us [N(Y)OO-klee-uhs]: the centre of an atom, 170–171

Old age: a late stage in the life cycle of a living thing, 62, 66, 70, 74
Or bit, 195, 199, 201, 203–206, 210, 212
Or ga niz ing: putting things in order so that they are easier to learn, 35
Ov a ry: the part of a flower that forms egg cells, 71–74
Ox y gen, 28, 76, 83, 121–122, 125, 127–128, 134, 136–137, 249, 269

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Pol lut ed [puh-LOOT-uhd]: unclean, 92, 180, 271, 274–276
Po ten tial [puh-TEHN-chuhl] **en er gy:** stored energy, 150
Pow er plant: 166–167; nuclear, 183
Prism [PRIHZ-uhm]: a glass which breaks a ray of white light into many colours, 154
Prom i nence [PROM(-uh)-nuhn(t)s]: hot layers of hydrogen shooting out from the sun, 223
Prop er ties [PROP-urt-eez]: the things which are part of you and of all matter, 98–111 / common, 98, 100–106; special, 98, 107–111
Pro ton: one of the particles of an atom, 114
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Ra di ant [RAYD-ee-uhnt] **en er gy,** 153, 155, 158
Ra dio waves: a form of radiant energy, 158, 160, 176, 223
Ra dio ac tive: able to give off particles from the nucleus of an atom, 170, 183
Ra di um [RAYD-ee-uhm]: a radioactive element, 170–171
Ray: a narrow path of radiant energy, 154, 170–171
Rea son ing, 37
Red gi ant stage: the stage of a star in which the star increases in size, 220
Re flec tor [rih-FLEHK-tur]: a kind of telescope made up of lenses and a mirror, 228
Re frac tor [rih-FRAK-tur]: a kind of telescope with two or more lenses, 228
Rep e ti tion [REHP-uh-TIHSH-uhn]: learning by doing things over and over, 34
Re pro duc tion [REE-pruh-DUHK-shuhn]: the means by which every living thing produces new living things that are like itself, 52–53, 56, 62, 78–80
Rep tiles [REHP-tuhlz], 58, 82, 85–86
Rev o lu tion [REHV-uh-LOO-shuhn]: the movement of the planets in orbit around the sun, 199
Rods: the sensory neurons in the eye which help you see at night, 9
Ro tate: to spin around in place on an axis, 203

Sal mon [SAM-uhn], 77–78
Sat el lite [SAT-uhl-YT]: an orbiting spacecraft, 231–233
Seed, 56–57, 60–61, 69–70, 74–75

Seed coat: a covering around the embryo of a plant and its food, 74
Self-concept: your mental image of yourself, 41
Semicircular canals, 13
Senses, 8–19, 26, 31
Sensory nerves: the nerves which carry impulses from the sense organs to the spinal cord or to the brain, 24
Sensory neurons [N(Y)OO-RAHNZ]: the special cells within the sense organs which collect information about the environment, 9, 11, 13–14, 16, 24, 27
Sex cells, 53–55
Simple reflexes [REE-FLEHKS-uhz]: reactions you were born with which enable your body to protect itself, 20–22, 27, 29–30, 35
Soil, 243–246, 253
Solar [SOH-lur] **energy:** energy from the sun, 173, 175–176, 181, 183, 222, 276
Solar flare: a short disturbance on the sun's surface, 222–223
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Sun spots: large, dark, cool areas on the surface of the sun, 224–225
Taste buds, 18
Telescope [TEHL-uh-SKOHP]: an instrument which makes a distant object look closer, 197, 227–230
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Trial and error: a kind of learning in which you try to do something until you find the right way to do it, 33

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Vibrate [VY-BRAYT]: to move back and forth quickly, 151
Volume [VOL-yuhm]: the amount of space something takes up, 105 / density and, 106

Water: a compound made from hydrogen and oxygen, 125–126, 246–248 / needs of embryo, 58; vapour of, 251, 253, 271
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Dr. E. R. Degginger: 13 (left), 18, 32, 38, 58, 70 (right), 89, 91, 242, 259 (right and top left), 260 (left), 267. Dr. E. R. Degginger/*Phil Degginger,* 271. A. Devaney, Inc.: 67, 179 (right), 187 (bottom), 205 (left), 231, 235, 249, 254, 256 (right). DeWys, Inc., 122. DeWys, Inc./*Victor Englebert,* 8. DeWys, Inc./*Francene Keery,* 99 (top). DeWys, Inc./*Ashwin Gatha,* 117. DeWys, Inc./*David Hamilton,* 149. Editorial Photocolor Archives/*Suntree:* 43 (bottom, left). *Dwight Ellefsen:* 14, 135 (bottom), 146 (both), 247. Freelance Photographers Guild/*Guy Gravett,* 182. Health Careers Council of Illinois, 44. Dept. of Health, Education and Welfare, 162 (left). *Grant Heilman:* 50 (all), 51 (all), 55, 57 (top left and bottom right), 60, 65, 83 (bottom), 130 (both), 156, 162 (right), 165 (bottom), 183, 216, 274. Grant Heilman/*Runk/Schoenberger:* 52, 57 (center), 70 (left), 83 (top and right), 154. Grant Heilman/*Runk/Rannels,* 53 (left). Grant Heilman/*Hal H. Harrison:* 85, 268. International Solarthermics Corp., 184. Lick Observatory, 201 (bottom). Miller Services/*Malak,* 236. Monkmeyer Press Photo Service/*Mimi Forsyth:* 22 (left), 101, 164. Monkmeyer Press Photo Service/*Bendick Associates,* 147. *Anne Morley:* 99 (bottom), 108, 129, 161, 187 (top). NASA: 201 (top, right), 206. NASA/*Jet Propulsion Laboratory, California Institute of Technology,* 203. Photo Research, Int.: 28, 29, 31 (all), 33, 42 (left), 92, 100, 104, 134, 135 (top), 165 (top), 176, 181, 201 (top, left), 207, 213 (both), 217, 221, 223, 224 (right), 225, 229, 264, 278. Root Resources/*Louise K. Broman,* 54 (both). Root Resources/*Anthony Mercieca:* 79, 80. Root Resources/*Ruth A. Cordner,* 86. Root Resources/*Barbara Adams:* 107, 127 (right). Root Resources/*Earl L. Kubis,* 204 (right). Tom Stack and Associates/*A. Blueman,* 62. Tom Stack and Associates/*Tom Myers:* 64, 243. Tom Stack and Associates/*Tom Stack:* 68 (left), 111. Tom Stack and Associates/*Bill Noel Kleeman:* 73, 185 (bottom). Tom Stack and Associates/*C. Kussner:* 204 (center), 224 (left). Tom Stack and Associates/*Regina P. Simon,* 244. Tom Stack and Associates/*William Eastman,* 260 (right). Tom Stack and Associates/*Warren Garst,* 277. Michael Sullivan/*Christopher Kuhn,* 186. Taurus Photos/*Alfred Owczarzak:* 53 (right), 68 (right). Taurus Photos/*Tom Myers,* 77. Taurus Photos/*J. R. Westlake,* 204 (left). Taurus Photos/*Arlton C. Murray,* 215. *Larry P. Trone:* 43 (right), 112, 124. *Paul Tucker,* 131. Van Cleve Photography/*Bob Smith,* 13 (right). Van Cleve Photography/*Dano,* 40. Van Cleve Photography/*Peter Fronk,* 42 (right). Van Cleve Photography/*David Kelley,* 43 (top, left). Van Cleve Photography/*David Muench,* 63. Van Cleve Photography/*Barbara Van Cleve:* 127 (left), 252. Van Cleve Photography/*Tom Meyers,* 179 (left). Van Cleve Photography/*James R. Simon:* 205 (right), 253, 256 (left and center), 259 (bottom, left). Van Cleve Photography/*James Marchael,* 218. Mt. Wilson and Palomar Observatories: 197, 214. Yerkes Observatory, University of Chicago, 220. Zefa/*W. L. Hamilton,* 12 (right). Zefa/*Icelandic Photo,* 16. Zefa/*H. Mante,* 22 (right). Zefa/*W. Mohn,* 37. Zefa/*Paul Freytag:* 41, 71. Zefa/*P. De Prins,* 113. Zefa/*Jack Novak,* 123. Zefa/*Hanx Schmied,* 133. Zefa/*Rosemarie Pierer,* 174 (top). Zefa/*J. Pfaff:* 174 (bottom), 178, 179 (center). Zefa/*H. Reinhard,* 265.

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